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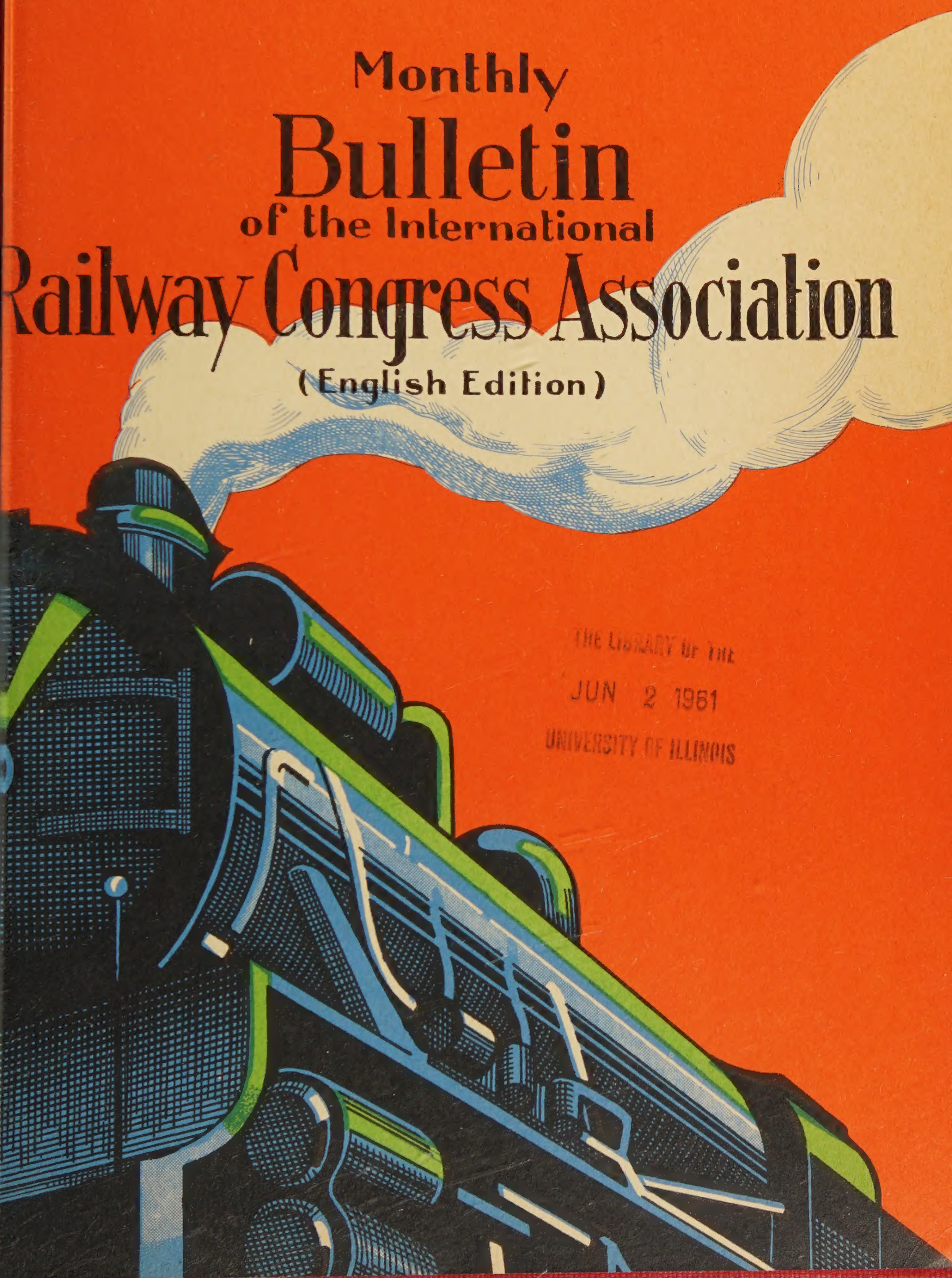

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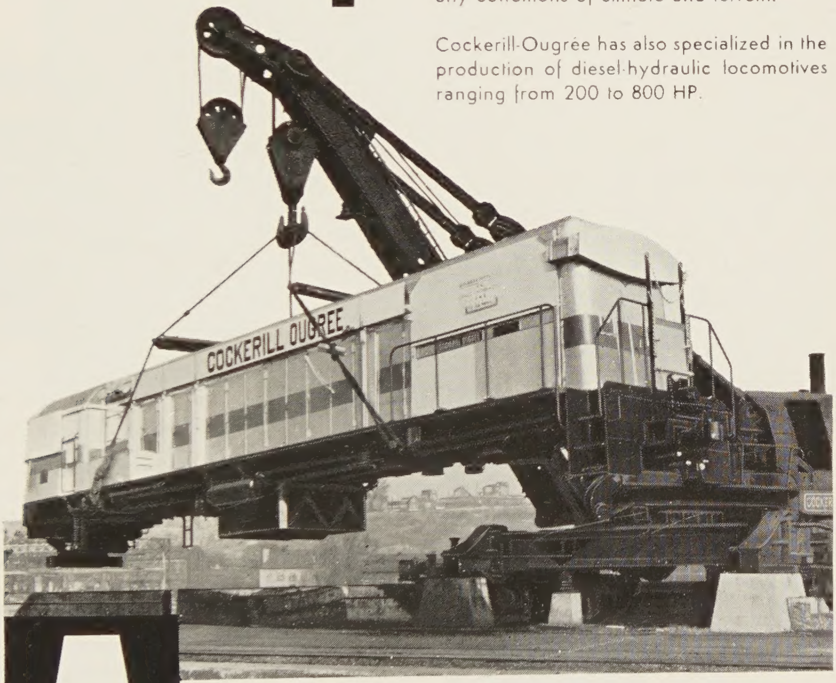

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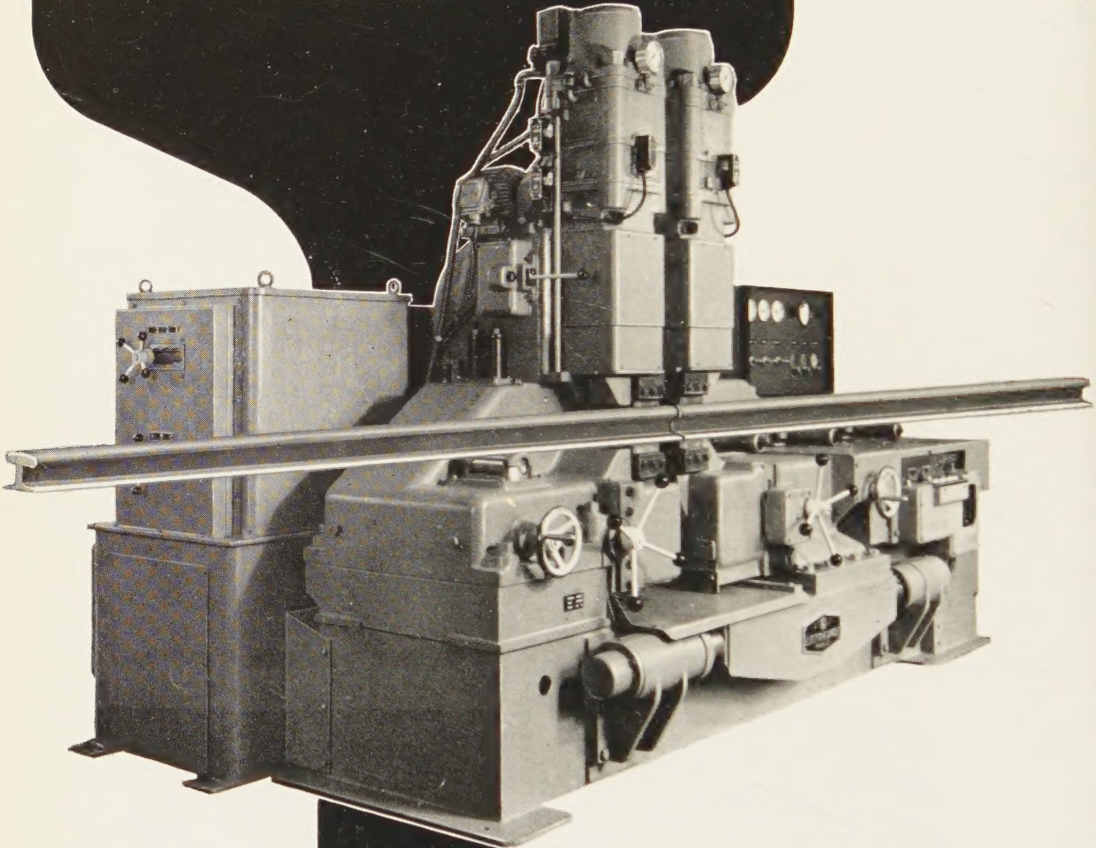

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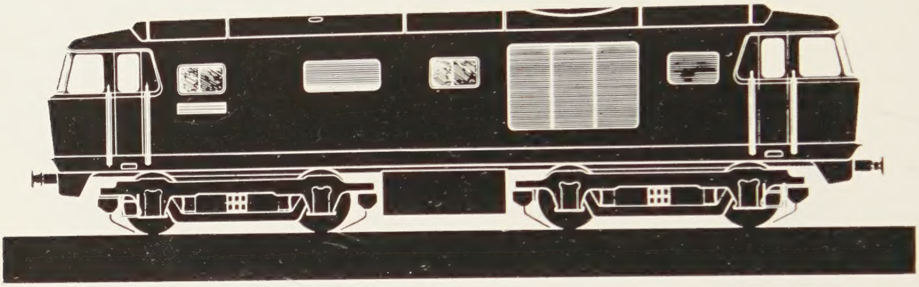

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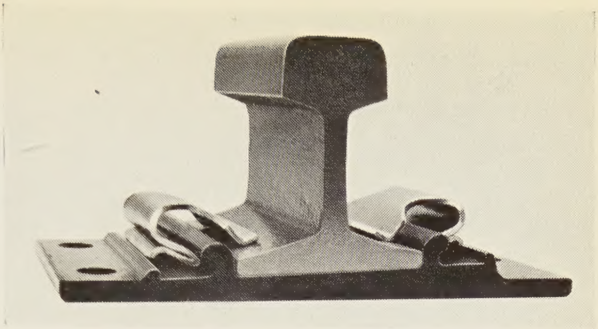

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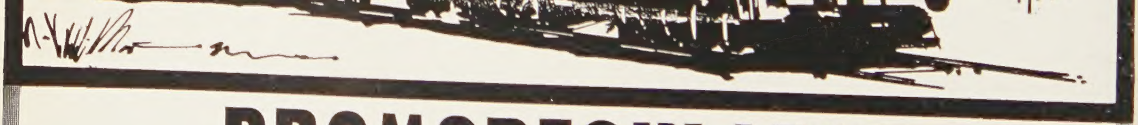

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[624 (43)]

New bridge structures for the electrification of the Hamburg — Hamburg-Bergedorf suburban line,

by Herbert CIESIELSKI, Dipl.-Eng., Hamburg.

(*Eisenbahntechnische Rundschau*, No· 6, June 1960.)

The extension of the Hamburg S-Bahn, or city railway system, to include the suburban line to Bergedorf necessitated some bridge building work. Of this, special interest is focussed on a large overhead crossing or fly-over in which prestressing was used for the first time in railway steel bridge construction, and on a roadway underpass notable on account of its small member cross-section and very low weight length ratio.

A. BRIDGE CONSTRUCTION FOR THE CONVERSION FROM STEAM TO ELECTRIC TRACTION

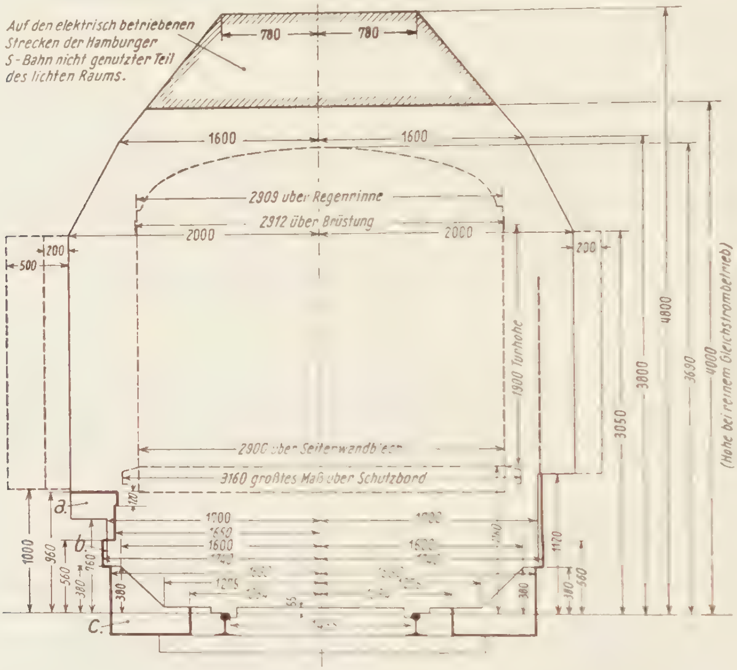
It may be somewhat surprising to find that the extension of electric suburban services to the Hamburg-Bergedorf suburban lines should have an influence on bridge construction. It is of course common knowledge that the overhead electrification of a long distance line, which requires a structure gauge with 5.5 m headroom to accommodate the overhead wire, calls for the raising of bridges where a headroom of 4.80 m had been adequate for steam traction. But one might not expect to come up against a similar problem in regard to electric suburban lines with their lighter axle loads, smaller car bodies, and current collection through a third rail for which little space is required — and that only at about axlebox level.

Yet it is the last-named, seemingly insignificant deviation from the normal structure gauge (fig. 1) which gave rise to the bridge reconstruction works. In the case of 22 engineering structures, it was necessary to prepare the bridge decking and guard rails and to provide new cable conduits. In the case of three bridges where the cross-section of the trough did not permit of the installation of the current rail, it was possible to solve the problem through raising the track by 15 to 20 cm. In these cases, it was found possible to accept the increased ballast weight after it had been established by refined methods of calculation that, if all the hidden reserves of the bearing capacity of the structure were taken into account, this capacity would be adequate. Certain supports, retaining walls and wing walls had to be reconditioned to enable them to take the increased load.

Among all the `modified or new bridge structures on the Hamburg-Bergedorf line, two (fig. 2) can be said to be of special interest :

— the viaduct at Berliner Tor station, where pre-stressing has been used for the first time in railway steel bridge construction, and

— the bridge across Hammerbrookstrasse, where a cross-section was adopted which resulted in the lowest-ever weight/length ratio in railway steel bridge construction.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2000
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1900 Türhöhe
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3160 größtes Maß über Schutzbord
a
b
c
1700
1650
1600
1205
1000
960
560
380
760
380
1120
380
560
3050
3800
4800
3690
4000
(Höhe bei reinem Gleichstrombetrieb)

Fig. 1. — Structure gauge of the Hamburg electric suburban lines.

a) Restriction of the normal structure gauge at station platforms;

b) Space required for the train stop device;

c) Space required for the current rail.

N.B. — Über Regenrinne = over eaves. — Über Brüstung = over window railings. — Über Seitenwandblech = over side wall panels. — Grösstes Mass über Schutzbord = maximum width over protection board. — Türhöhe = height of door. — Höhe bei reinem Gleichstrombetrieb = headroom with D.C. working only. — Auf den elektrisch betriebenen Strecken = part of the structure gauge not utilized on the Hamburg electric suburban lines.

B. VIADUCT AT BERLINER TOR STATION

I. The structure as a whole.

With this structure (fig. 3), the foundation conditions were not particularly favourable. The rail level of the bridge is at approx. +12.00 m above datum whilst the ground water table is at +0.10 m, and firm bearing soil at —7.50 m. The site is part of the Hammerbrook tract which used to be a marsh or moor. When, in 1903, the tracks of the Hamburg-Berlin line were raised, the ground was generally raised to the level of +7.00, and the structures were founded on wooden piles of 7.50 m length. The choice of the cap level was governed by the highest water level so that the structures carried by the pile platform had a height of approx. 12 m. A similar method of foundation for the new viaduct would have called for concrete piles of about 12 m length and would have been very expensive as it would have been difficult to drive the piles between the tracks. As

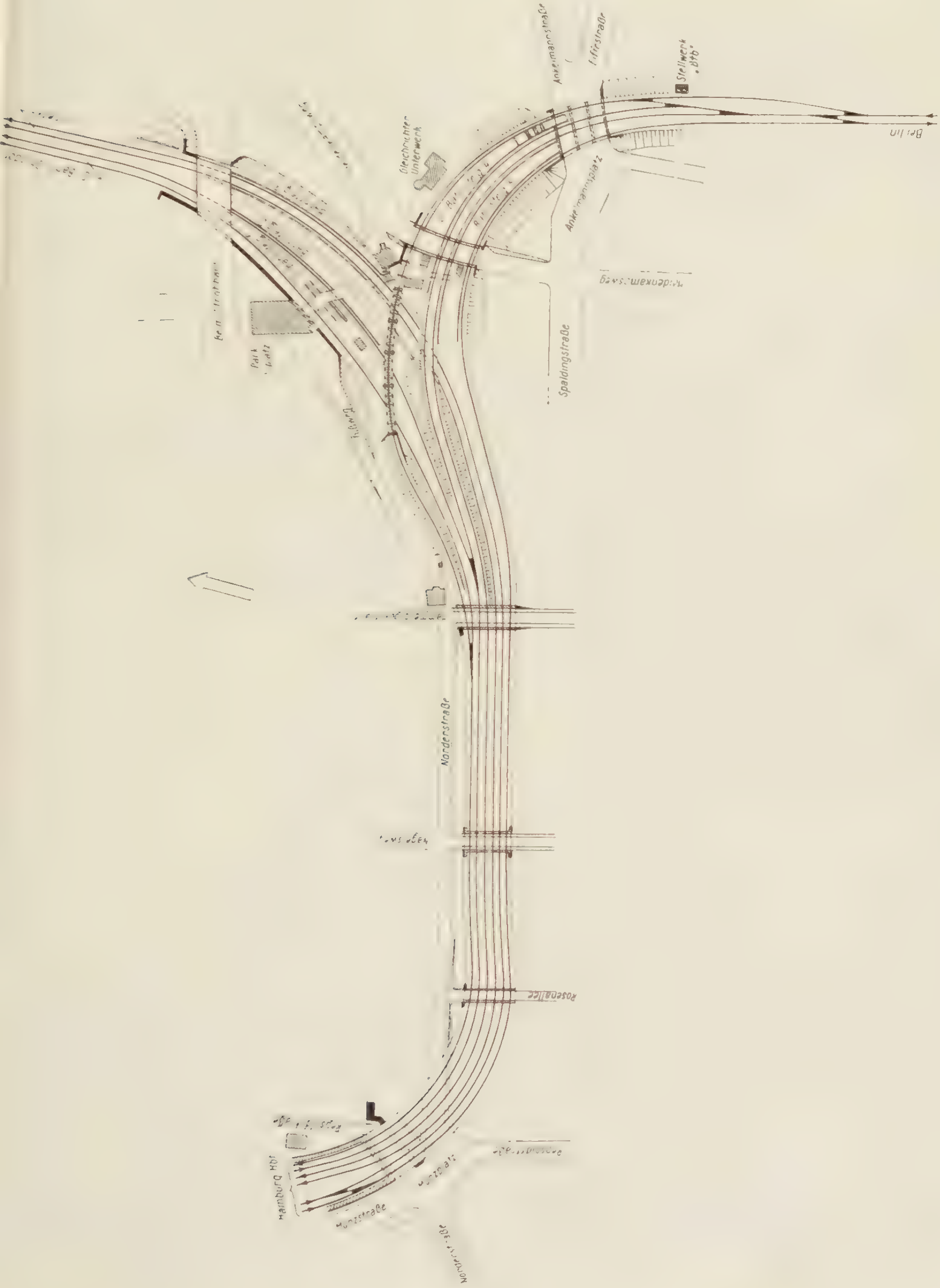


Fig. 2. — Plan of railway installations in the vicinity of Berliner Tor station.
N.B. — Bahnsteig = platform. — S-Bahnsteig = suburban line platform. — Stellwerk = signal box.

the 60 to 80 cm thick strata of moor have been subjected to the load of the embankment fill for fifty years already, it is reasonable to assume that the water has by now been squeezed out by the additional load. It was therefore decided to place the new piers and abutments for the statically determinate bridge structures on shallow foundations. To save weight and to keep the ground-bearing pressure small, the new abutment was designed as a cavity structure whilst the piers were designed as steel gantries. If settlements are experienced, these can be subsequently adjusted by means of adjusting devices at the supports.

The viaduct consists of seven new spans. The three at the eastern end, Nos. 1 to 3, have a uniform length of 10.58 m each, the fourth span, bridging the tracks to and from Lübeck, is 19.60 m long, the fifth has a length of 17 m, whilst the two last ones have a length of 39 m each. Certain structures and piers still available from an earlier flyover in approximately the same alignment, which had been removed in 1934, were not suitable for the suburban structure gauge. Moreover, their reconstruction would have been very expensive due to changes in levels.

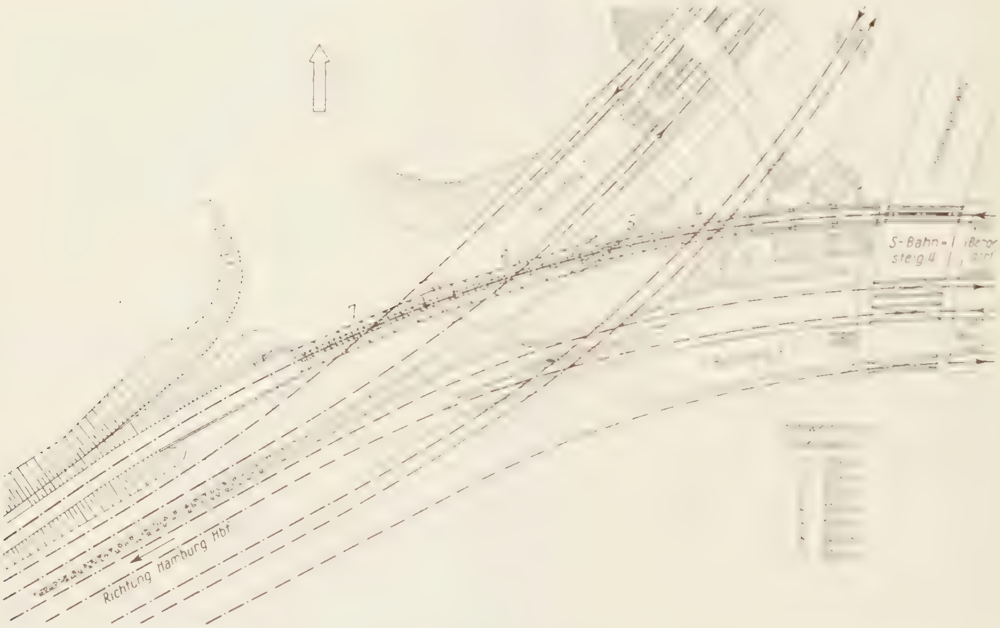


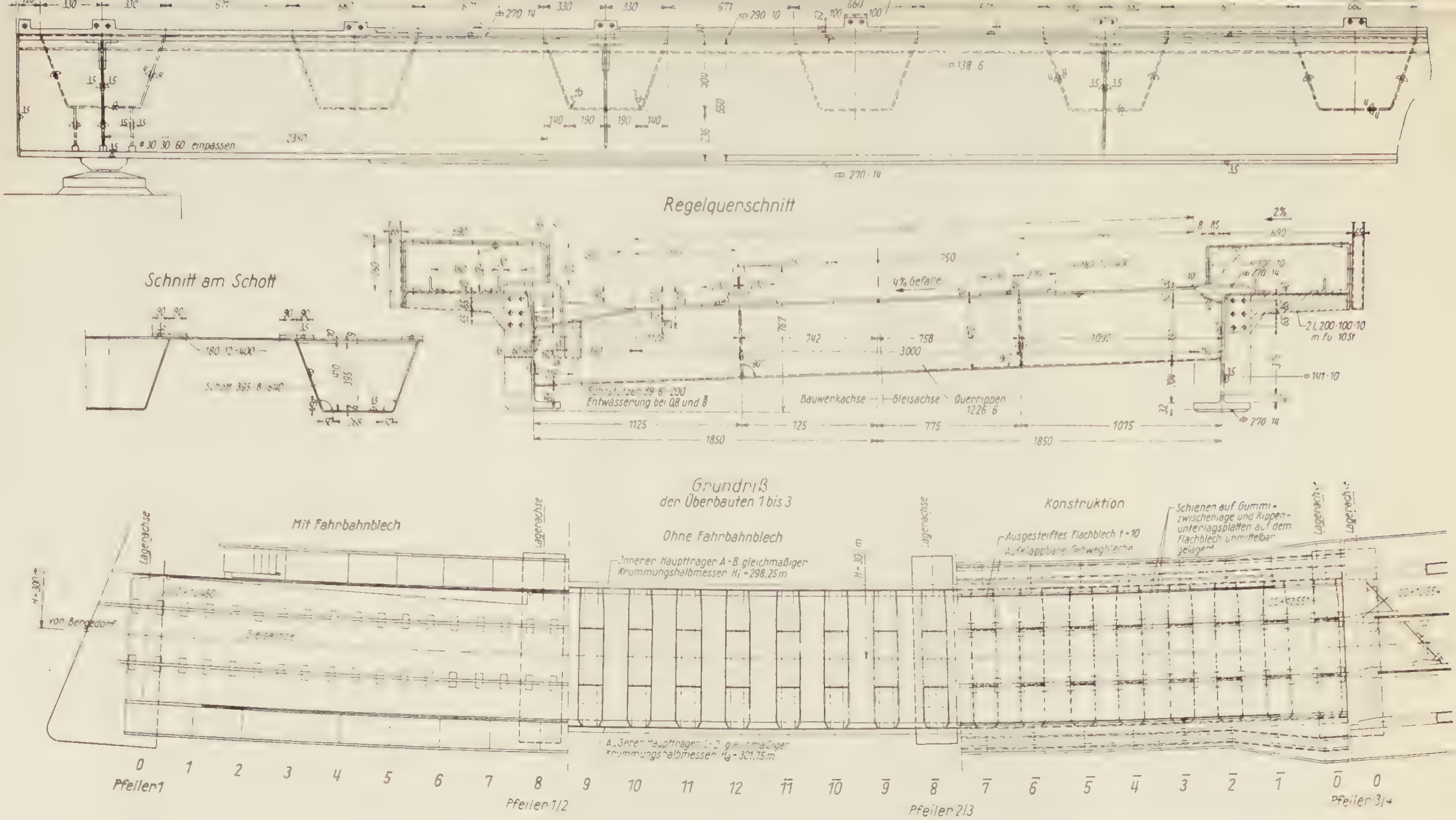
Fig. 3. — Plan of new flyover at Berliner Tor station.

N.B. — Stützweiten der Oberbauten = bridge spans. — Richtung Hamburg Hbf = to Hamburg Central Station. — Von/nach = from/to. — Bahnsteig = platform. — S-Bahnsteig = suburban line platform.

II. The three Eastern bridge spans.

Spans 1, 2 and 3 have been constructed as continuous girders over three spans, without ballast, with a deck composed of flat steel, and with rubber supported permanent way. This design, illustrated in figure 4, has enabled the height of construction to be reduced to as little as 0.79 m.

Each span is composed of the two main girders, spaced at 3.7 m centres. They consist of wide-flanged beams IP 65 which are reinforced by welded flange plates at the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Entwässerung bei 0,8 und 8
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1125
725
775
1075
1850
1850
Grundriß
der Überbauten 1 bis 3
Mit Fahrbahnblech
Ohne Fahrbahnblech
Konstruktion
Lagerachse
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Äußerer Hauptträger gleichmäßiger Krümmungshalbmesser Ha = 301,75 m
Ausgesteiftes Flachblech t = 10
Aufklappbare Gehwegbleche
Schienen auf Gummizwischenlage und Rippenunterlagsplatten auf dem Flachblech unmittelbar gelagert
von Bergedorf
Pfeiler 1
Pfeiler 1/2
Pfeiler 2/3
Pfeiler 3/4

Fig. 4. — Plan of flyover spans 1, 2 and 3, and elevation and sections of one span.

N.B. Ansicht elevation. Leiste zur Befestigung der Gehwegplatten footway plate support bar. — Regelquerschnitt normal cross-section. — Gefälle crossfall. — Rohrstutzen section of pipe. Entwässerung drainage. — Bauwerkachse — centre line of structure. — Gleisachse centre line of track. — Querrippen cross ribbing. — Schnitt am Schott cross-section at diaphragm. — Schott diaphragm. — Grundriss der Überbauten 1 bis 3 plan of spans 1 to 3. — Mit Fahrbahnblech = with deck plating. — Ohne Fahrbahnblech without deck plating. — Pfeiler pier. — Gleisachse = track centre line. — Lagerachse – bearing centre line. — Innerer Hauptträger – inner main girder. Äusserer Hauptträger outer main girder. — Gleichmässiger Krümmungshalbmesser – constant curve radius. — Ausgesteiftes Flachblech reinforced flat plate. — Aufklappbare Gehwegbleche hinged footway cover plates. — Schienen auf rails resting directly on the flat plate by means of rubber pad and ribbed tie plates.

supports and mid-span zones exposed to the highest bending moments, and which follow the curvature of the track, with a curve radius of 300 m. In this way, it was possible to reduce the main girder spacing to a minimum so that the width of the bridge deck, the length of the box-type cross-girders, and the weight of the bridge deck could be reduced.

The bridge deck proper, placed at the level of the top flange of the main girders, consists of non-ballasted, enclosed 10 mm thick plating which, together with the trapezoidal cross-stiffeners built up from folded plates, forms a number of box girders of hight torsional rigidity. These are particularly well suited for the torsional stress, caused by the wheel loads, to be absorbed in the form of shear stress. This bridge deck structure, which has not secondary rail bearers, is particularly economic.

The spacing of the box-type cross-girders is approx. 1.32 m. Their webs come to lie below the tie-plates supporting the rails. At the points where the loads are introduced, transverse diaphragms are welded to the box girders so as to maintain the torsional rigidity and the correct shape of the box girders. If I-beams had been chosen as cross-members, it would have been necessary to provide one at each tie plate. This would have increased the weight by 700 kg, and the aggregate length of the welds by 130 m. With the design eventually adopted, each cross-member carries the weight from two tie plates. The design has resulted in an aesthetically satisfactory, smooth underside view of the superstructures (fig. 5).

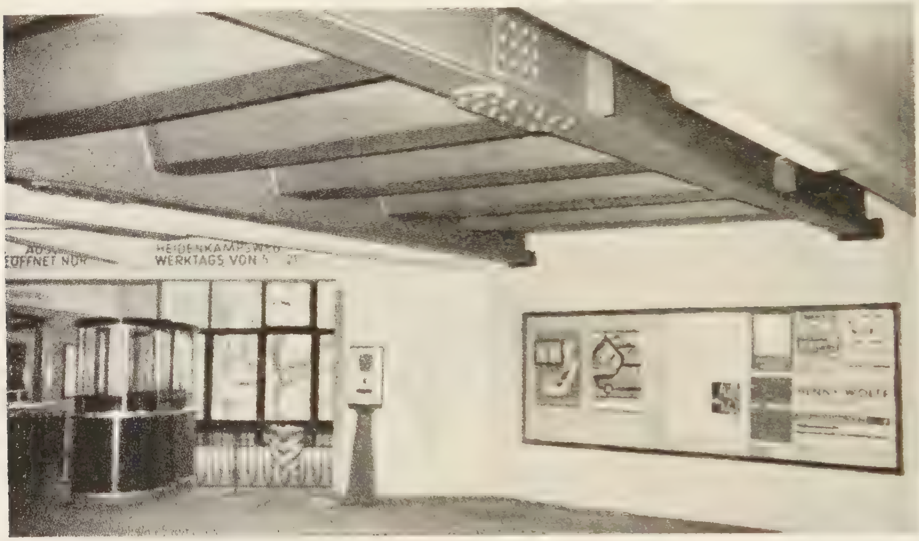

Fig. 5. — Underside view of span 2, above the entrance to the platform of the Bergedorf line.

The footway structure consists of the corbels, edge beam, inner longitudinal beam, the beams bearing the cable conduit which rests on the corbels, and the hinged warted plates of the footway which consist of separate panels and also serve as cable conduit covers. The railing posts are hollow steel sections, and the railing bars angle irons.

A mid-span joint, required for erection purposes, extends over the whole cross-section of the bridge. Superstructure and footway structure, both consisting of M St 37 steel, are all-welded except for the mid-span joint and the connections between these two structures which are riveted *in situ.*

The fixed and expansion bearings of the bridge consist of cast steel, GS 52.1. In the vicinity of the bearings, the cross-girders are protected against overturning by means of tie rods and turnbuckles. Those at the ends of the bridge are also protected against lifting by means of anchors embedded in the piers.

III. Spans 4 to 7.

Consideration was given to the question whether a section of spans 4 to 7 should be replaced by an embankment but this was found to be uneconomic and undesirable. Because of the poor subsoil, the long parallel wing walls which would have been necessary would have been more expensive than the steel spans. Morevoer, visibility on the approach to the station would have been impaired to an undesirable extent. It was therefore decided to use steel spans.

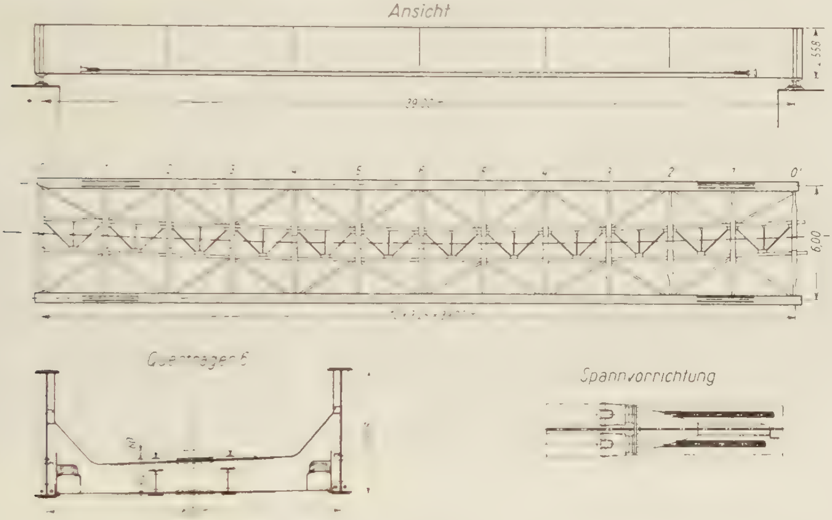

Fig. 6. — Prestressed flyover span.

N.B. — Ansicht = elevation. — Querträger = cross-girder. — Spannvorrichtung = tensioning device.

Spans 4 and 5 do not offer any special features. In contrast, spans 6 and 7 which bridge the Ohlsdorf stem line and therefore require larger spans, are distinguished by the fact that they are, for the first time in railway steel bridge construction, designed as prestressed structures.

a) *Prestressed steel spans 6 and 7.*

1. *Basic principles, calculations, and testing programme.*

Spans 6 and 7, each 39 m long, are situated in a curve of 386 m radius, with a rise of 60 cm. Taking into account the relative levels of the old suburban line below and the new line on top, one obtains, for the two straight main girders, a spacing of 6.0 m (fig. 6). If the main girders had been given the conventional height of one-tenth of their length, i.e. 3.90 m, they would have obscured a large part of the train windows. This would have run counter to the passengers' wish for a free view, and was to be avoided if that could be done without economic sacrifice. Also from an aesthetic point of view, main girders of such great height would have provided an unsatisfactory appearance from the platform of the low-level line which is crossed at an acute angle. It therefore seemed logical to reduce the height of the girders by resorting to prestressing. Even if this first trial with prestressing in railway steel bridge construction would not have provided a fully convincing structural solution, the risk was not unduly great.

Having regard to possible diversions of main line trains, and to the use of cranes, the bridges of the Hamburg suburban system are designed for loading diagram S, corresponding to a weight of 10.4 t/m. The normal suburban trains, however, weigh no more than about 4.0 t/m. It was therefore specified for the construction of the prestressed bridge that the spans should be able to carry the normal, comparatively light suburban trains even without the aid of the prestressing device, whilst the latter would have to be used in the event, which may occur seldom or never, of the bridge being needed for loads of the magnitude of loading diagram S. Finally, it was laid down in connection with the proposed prestressing that this method should be economically superior, or at least not inferior. The solution developed on this basis is illustrated in figures 7 and 8.

In view of the novelty of the task, an extensive research and testing programme was required in order to verify the theoretical assumptions as well as the agreement between theory and practice. This programme comprised :

at the works:

- testing of the cables and determination of the modulus of elasticity;
- testing of the cable heads;

at the works and on the site :

- determination of the cable forces introduced;
- determination of the web plate stresses in the vicinity of the tensioning device;

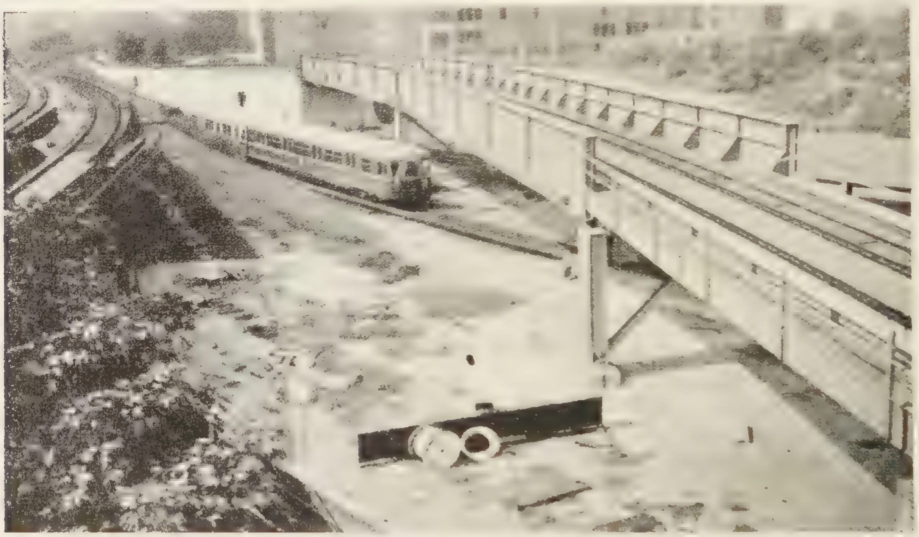

Fig. 7. — Prestressed spans at the western end of Berliner Tor station.

— investigation of the stress configuration in main girders, deck and bracings;

in the finished structure :

— investigations on the effect of running trains.

The tests were carried out with the bridge testing train of the Central Office of the German Federal Railways, Munich.

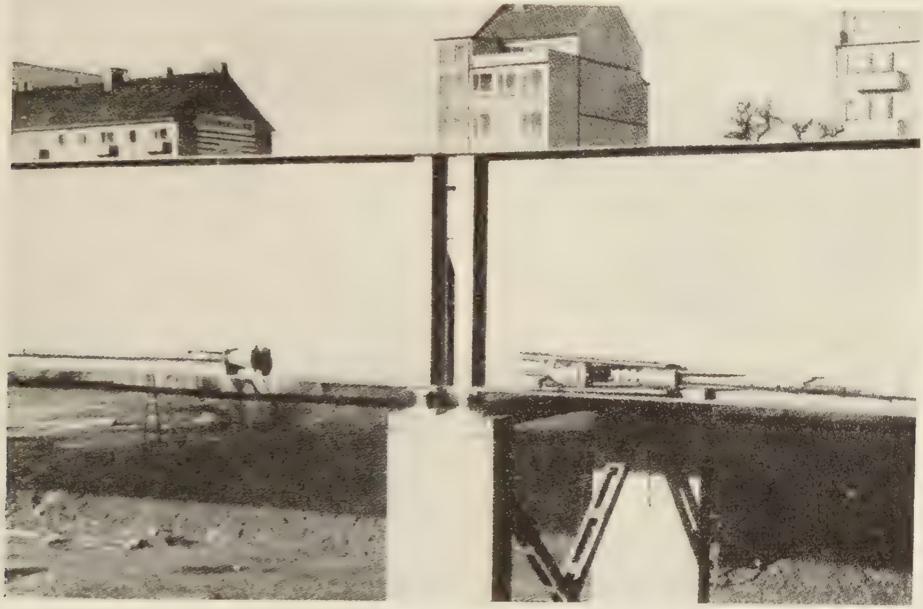

Fig. 8. — Prestressing cable heads. At the head on the right, the hydraulic appliance has not yet been removed.

2. *Testing of the cables, and determination of their modulus of elasticity.*

Due to the method of manufacture and to heir structure, the modulus of elasticity of cables differs greatly from that of their basic material. But if cables are to be used for tructural purposes, an exact knowledge of he modulus of elasticity is indispensable. For that reason, a 3 m long specimen of a patent-sealed cable of 59 mm diameter, with he same characteristics as the cable which was to be used for the bridge, was subjected to a special test (fig. 9). An initial load of 10 t was raised, step by step, to 30, 50, 70, 90 and finally, 110 t, corresponding to the prestressing load required at the bridge. Subsequently, the load was made to fluctuate ten times between 110 t and the traffic load of 140 t, and another three times between 110 and 160 t, followed by the destruction of the cable in order to determine its actual ultimate load. The stress/strain curve based on the test results yielded a mean value of $E = 1.6 \times 10^6$ kg/cm^2. A fatigue strength test was not considered necessary as the fluctuation range in normal service is very small. With an initial stress of 4.64 t/cm^2, this range is no greater than 0.44 t/cm^2, even with loading diagram L; it is very much smaller with the electric suburban trains which are virtually the only trains to use the bridge.

An investigation has also been carried out into the question of the twist of the cable head caused by traffic loads. This twist, where the cable remains straight while the superstructure and the cable head fixed to it are sagging, may amount to 1°. The cable head twist will have about the same effect as a shearing force of the kind exerted in the tests carried out by Klingenberg for the cables of the Rodenkirchen bridges. According to the results of these tests, (1) the cable subjected to a shearing force and to a basic stress of 4.3 t/cm^2 was able to sustain 2 million cycles of a stress fluctuation of 1.5 t/cm^2 without showing fatigue effects. Having regard to the frequency of the maximum values proved by calculation, and to the small amplitude of the stress fluctuations actually occurring in normal operation, it was regarded as unnecessary to take special measures at the cable heads.

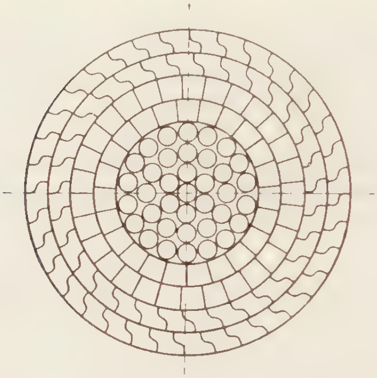

Fig. 9. — Cross-section of prestressing cable (59 mm dia.).

Cable structure		Tensile strength
1 round wire 3.50 mm 36 round wires 3.25 mm		160 kg/mm^2
21 / 26 wires of trapezoidal cross-section	4.50 mm thick	150 kg/mm^2
29 / 34 «S»-wires	4.50 mm thick	140 kg/mm^2

Length of lay = 10 D; nominal cross-sectional area 2492 mm^2; theoretical ultimate load 365 t; actual ultimate load ascertained during acceptance test on 14th February 1958 : 340 t; delivered by Westfälische Union A.G. für Drahtindustrie, Lippstadt Works.

3. *Testing the cable heads.*

The examination of the cable heads, which consist of cast steel GS 52.1, was intended to ascertain their performance when their lugs are subjected to a load of 55 t per lug corresponding to the prestressing of the cables in the structure. In particular, it was intended to determine the deformability of the material and the ultimate load of the cable heads, as well as the slip of the interlocking cone, cast in high-grade zinc in accordance with German Standards DIN 1706, with which the cable is held in the cable head. The degree of slip was measured at a load of 5, 10, 20, 30, 50, 70, 90, 110, 130 and 140 t, respectively (fig. 10). The penetration of the compound and the wires into the cable head was measured at point A, and the emergence of the cable from the cable head at another point, B. With a load of 140 t, these two measurements were nearly identical, viz. 3.26 and 3.30 mm, respectively. When the load was increased further, one of the lugs was destroyed at 344 t. The safety factor of the cable heads, with a prestressing load of 110 t, was thus 3.1. A test carried out on a second cable head yielded similar results.

4. *Determination of the cable forces introduced.*

The cable forces were determined from :

a) the pressure gauge readings at the hydraulic jacks;

b) the cable elongations measured at the prestressing appliance;

c) the elongations measured at the cable ends;

d) the elongations measured at the draw plates;

e) the frequencies of the cable vibrations.

According to the results of earlier calibration tests, there exists, between the cable force S (in t) and the vibration frequency *f*

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(1) Special brochure « Rodenkirchen », p. 52.

(c/s), the simple relationship $S = 9.3\ f^2$. This is used, in particular, for subsequent measurements, without costly testing apparatus, of the stress decrease in the cables due to creep.

The theoretically necessary prestressing force of 115 t was applied at the works in several stages, and was again removed after the measurements referred to under (*d*) and (*e*) above had been taken. Before the girders were transported to the site, they were subjected to half the prestressing force in order to anticipate part of the creep which is a function of time. During the tests on the site, carried out in the time from 7th to 10th April, 1959, the cable force was found to drop at the rate of about 1 t per day, which must be ascribed to the elasticity of the cable anchorage and the creep in the cable itself. Through post-tensioning. and inserting 5 mm thick plates, the full prestressing force of approx. 116 t was eventually restored. By connecting the four hydraulic appliances in parallel to the same hydraulic system, it was possible to obtain an even stress in all the four cables. A cable vibration test carried out on 17th September 1959 revealed, as expected, a decrease of the cable force to roundly 109 t, the individual results being as follows :

	Span 6	Span 7
A *a*	108 t	106 t
A *i*	112 t	109 t
B *i*	111 t	109 t
B *a*	109 t	109 t

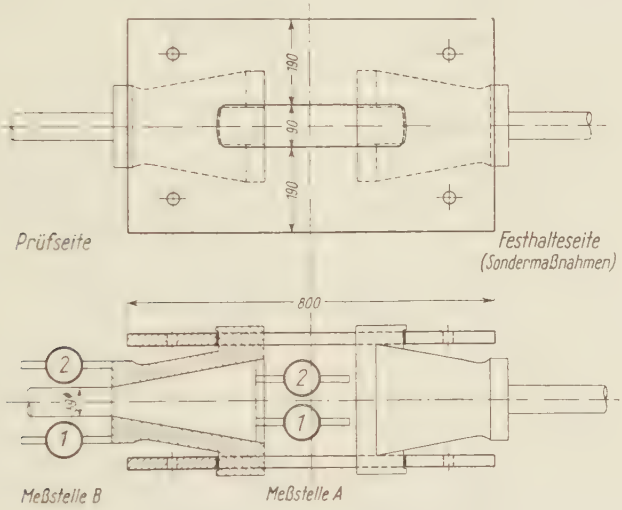

Fig. 10. — Device for testing the cable head lugs.

N.B. — Prüfseite = testing side. — Festhalteseite (Sondermassnahmen) = fastened side (special measures). — Messstelle = measuring point.

The cable forces are still being observed, especially in view of the fact that an acceleration of creep is expected to take place as a result of the traffic load after the commisioning of the bridge on 4th October, 1959. Experience indicates that a state of stability will be reached, and that the creep will cease.

An important factor is also the variation in the cable force under traffic. During a load test carried out with two Class 44 steam locomotives which, with a service weight of 190 t each, are at present the heaviest locomotives of the German Federal Railway, and by which the main girders were subjected to a load corresponding to 73 % of loading diagram S, the cable force was found to increase by 11 t. The cable frequency increased correspondingly from 3.52 c/s for the bridge without load to 3.70 c/s for the loaded bridge. Even a simple rhythmic excitation by hand showed that it was possible to generate considerable amplitudes of the freely vibrating cable by means of small but resonant forces. The resonance position is governed by the natural frequency of the bridge which amounts to 3.8 c/s without load, and up to 2.0 c/s (depending on the magnitude of the load) under load. The amplitudes observed, viz. ± 4 mm during runs with two locomotives, and ± 7 mm during runs with one locomotive, were small; but they are likely to be somewhat greater with the lighter load of the suburban trains. It must not be overlooked, either, that a much greater displacement (approx. 60 mm) of the centre of the cable in relation to the superstructure is caused by the sag under the load of two Class 44 locomotives. In order to prevent vibrations, the cable was therefore fixed at two points.

5. *Web plate stresses in the vicinity of the prestressing appliances.*

In the vicinity of the prestressing appliances, the web plate was reinforced, from 12 to 24 mm, over the length of the first panel (3.25 m) and to a level of 760 mm above the bottom flange so as to permit, without risk, the introduction of the high cable force. Measurements revealed a high eccentric stress in the vicinity of the prestressing appliance, amounting to + 990 kg/cm^2 on the inside and — 136 kg/cm^2 on the outside so that it was indicated to extend the stiffenings of the prestressing appliance far into the next panel. This resulted in a nearly symmetric stress.

6. *Examination of stresses in main girders, deck and joints.*

To a not inconsiderable extent, the main girder stresses are influenced by the way in which the bridge deck and the joints are connected with the main girders. If the bond effect is taken into account, the theoretical and measured values show a good agreement. That the measured values are generally lower is, as usual, due to the greater rigidity of the connections and to the friction in the bearings, but also to other influences which, with three-dimensional structures, cannot be taken into account in the calculation through simplifying assumptions.

7. *Examination of the behaviour of the bridge under traffic.*

The dynamic coefficients ascertained on the occasion of the determination of the stresses introduced by one and two Class 44 locomotives passing over the bridge at a maximum speed of 54 km/h were found to be around $\varphi = 1.15$, a value considerably below the BE values of $\varphi = 1.32$ for a girder of 39 m span. A similar picture was obtained of the dynamic coefficients for the cross-girders and bearers.

b) *Economic assessment of the prestressing solution adopted.*

It remains to answer the question whether the prestressing solution adopted for this bridge at Berliner Tor has been economically superior to conventional methods or whether it has, at least, given rise to the expectation that the method will be economically superior after adoption of certain modifications to the structural elements and materials here used.

The first part of this question can be commented upon as follows : An exact comparison of weights and prices is a very difficult proposition since an exact calculation of the system which, due to the prestressing and the active contribution of the bridge deck, is statically indeterminate to the seventh degree, would call for an excessive mathematical effort. The examination has therefore been confined to a comparison of the prestressed main girders with non-prestressed girders, the active contribution of the bridge deck being taken into account by way of approximation only, whilst deck, joints, bearings and stiffeners were deemed to be identical in both cases.

The weight comparison of the main girders showed the following results :

— for a prestressed superstructure, excluding the weight of the cable, 35.9 t of Steel 52 and 7.0 t of Steel 37, to which must be added 3.28 t for the prestressing parts, a total of 46.2 t;

— for a non-prestressed superstructure with the same deflection, 45.6 t of Steel 52 and 4.7 t of Steel 37, a total of 51.3 t.

If the weight of the deck, 43.6 t, is included, the total weight of the prestressed bridge (approx. 89.8 t) is about 5 % lower than that of the non-prestressed bridge (94.9 t).

If the prices are compared, the cost of the prestressed structure is found to be DM 2 800 higher than that of the non-prestressed structure. In looking for the reasons for this unexpected result, it must be remembered that the contractor's offer was mainly based on the use of Steel 52. It was obvious from the outset that the economic advantage of prestressing would be more pronounced in the case of a steel with lower ultimate strength. But as no experience was available with prestressed steel railway bridges, it was necessary to ensure that, if the experiment should be unsuccessful, the bearing capacity remaining after the elimination of prestressing should still be as high as possible. For that reason, the use of Steel 37 was greatly limited.

Further comparative calculations were therefore carried out in order to ascertain the costs in the event of Steel 37 being used exclusively. It was found that the prestressed structure would then have a weight of 47.94 t, plus 3.28 t for the prestressing parts, i.e. a total weight of 51.2 t. The weight of the non-prestressed structure would be 59.8 t. The weight advantage of the prestressed structure would therefore be greater, and also the price comparison is, this time, in its favour to the extent of 1 800 DM.

That the prestressing of the welded railway bridge at Berliner Tor did not prove to be economically superior is also due to the fact that, without traffic load, the prestressed superstructure is subjected to compressive stresses only, whilst the bottom flange of the non-prestressed girder has tensile stresses. Under traffic, the stress in the bottom flange of the prestressed girder changes its sign, whilst that in the non-prestressed girder is merely intensified. According to the German regulations DV 848, however, the maximum permissible stress in welded structures is considerably lower for alternating stresses than for fluctuating unidirectional stresses. This feature is more pronounced for Steel 52 than for Steel 37. It must also be taken into account that in the web plate, as a result of prestressing, the K value, i.e. the ratio min σ_D/max σ_D, changes from + 1 to — 1.

It has not been demonstrated that the adopted prestressing force of 230 t per girder does in fact respresent an optimal solution. Although the optimum may be expected to lie around 280 t, it must not be overlooked that the extra cost of stronger cables increases rapidly and that, to some extent, the K values too become less favourable.

With the non-graduated type of prestressing here adopted, the prestressing cables should have been made not quite so long. The probably most favourable distance of the cable heads from the bearing is thought to be at least 6 m, compared with the distance of 2.5 m actually chosen. This, too, would have entailed a minor saving.

A further reason for the lack of economic success must no doubt also be seen in the fact that the cables have been arranged in a straight line over almost the whole length of the bottom flange, without graduation. It is undoubtedly more economic to adapt the prestressing forces, and hence the bending moments generated by them, to the local statical requirements. This might, for instance, be achieved by the symmetrical shifting of the individual prestressing cables suggested by Professor Fritz (2) where the cables overlap in the mid-span zone, or by local reinforcements of the cable. Admittedly, this would call for an increased number of cable heads, and for more prestressing work. Even an approximately parabolic alignment of the prestressing cable would enable the prestressing force to be better adapted to the requirements at each cross-section though, in this case, it would be necessary to overcome certain structural difficulties at the cable guide points.

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(2) *VDI-Zeitschrift*, Vol. 98 (1956), No. 22, p. 1280.

Another reason for the lack of economic success is the low maximum stress of 5 800 kg/cm² permitted for the prestressing cable (³). For a centrically prestressed steel prism, H. Sossenheimer (⁴) states the following ratio of the total costs K_v of the prestressed prism, including the cable, and the total costs K of a non-prestressed, homogeneous prism :

$$\frac{K_v}{K} = \frac{zul\sigma_z}{\sigma_1 + zul\sigma_\alpha} \cdot \frac{\beta zul\sigma_k - \sigma_1 - zul\sigma_\alpha - \beta zul\sigma_\alpha \cdot k_k - \beta zul\sigma_\alpha \cdot k_k : k}{\beta \cdot \sigma_{k1} - \sigma_1} .$$

Without taking into account the reduction in permissible stress due to alternating loads, the variables contained in the formula assume, in our case and for Steel 52, the following values :

$zul\sigma_z$ = permissible tensile stress in the steel prism = 2 400 kg/cm²,

$zul\sigma_\alpha$ = permissible compressive stress in the steel prism = 2 100 kg/cm²,

$zul\ \sigma_k$ = permissible steel stress in the prestressing cable = 5 800 kg/cm²,

σ_{k1} = cable stress due to prestressing and extraneous load = 5 800 kg/cm²,

σ_1 = final stress in the prism due to prestressing and extraneous load = 2 100 kg/cm²,

E_k = modulus of elasticity of the prestressing cable = 1.6,

$\beta = \frac{E}{E_k} = \frac{2.1}{1.6} = 1.31$,

k = unit cost of structural steel = 2 222 DM,

k_k = unit cost of prestressing cable = 6 620 DM.

Substituting these values for those in the formula, one obtains a ratio of $K_v : K = 1.2$. Even under these conditions, the prestressed structure would thus be 20 % more expensive than the non-prestressed structure. If the prestressing cable were replaced by tensioning rods 140/160 under the conditions and rules of prestressed concrete construction, with $\beta = 1$ and $zul\sigma_k = 0.55 \times 16\,000 = 8\,800$ kg/cm², one would obtain a cost ratio of $K_v : K$ = approx. 0.92. In this case, the prestressed structure would entail a saving of approx. 8 %, assuming the same ratio of k_k/k which is, however, likely to become smaller.

Corresponding calculations for Steel 37 yielded a cost ratio of $K_v : K$ = approx. 0.98 (i.e. a saving, through prestressing, of approx. 2 %) for prestressing by cable, and a cost ratio of $K_v : K$ = approx. 0.81 (i.e. a saving of 19 %) for prestressing by tensioning rods.

Although, strictly speaking, these cost ratios apply to centrically prestressed bodies only, it is permissible to conclude that, even with an eccentrically prestressed body, e.g. a bridge girder, the essential requirement is that there should be a major difference between the permissible stresses of the prestressing steel and those of the structural steel.

C. NEW BRIDGES ACROSS HAMMERBROOKSTRASSE

I. Previous conditions.

In the vicinity of Berliner Tor station, the electrified suburban lines cross Hammer-

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(³) Draft Standards DIN 1073, ultimate strength of individual wires 16 000 kg/cm², yield limit 14 000 kg/cm².

(⁴) *Der Stahlbau*, 1951, No. 10.

brookstrasse on a structure which used to comprise an 11.60 m long main span across the carriageway, and two 2.50 m spans across the two lateral footways. The ballasted spans used to rest by means of Gerber type hinges, on the columns which were always in danger of being damaged by colliding road vehicles. Abutments and column foundations rest on wooden piling of 10 m length.

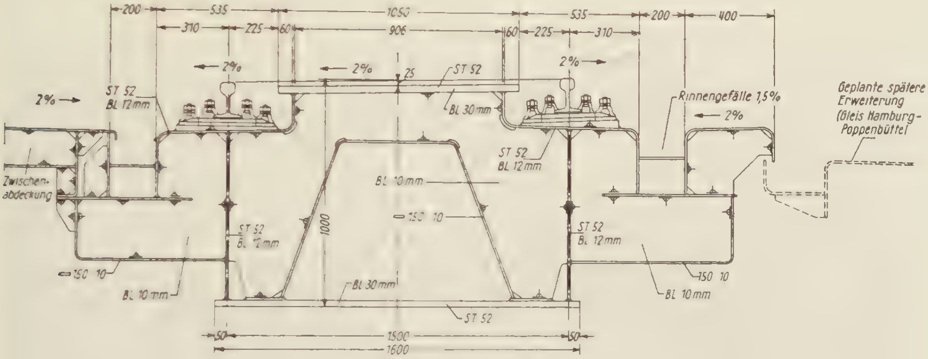

Fig. 11. — Cross-section of bridge span accross Hammerbrookstrasse.

N.B. — Zwischenabdeckung = intermediate cover. — Rinnengefälle = gutter crossfall. — Geplante spätere Erweiterung = proposed future extension (track from Hamburg to Poppenbüttel).

II. Design of the new bridge spans.

The only design suitable for the two new bridges carrying the electrified line to Bergedorf was a girder bridge over the whole span of 17.80 m. In view of the structural height of 1 m required for this purpose it was necessary to forgo the ballast, a decision with important consequences. The old abutments were so amply rated that, when the column foundations were included, the necessary modifications and additions to the solid structural parts were small. All the more thought had to be given to the superstructures which were designed as box girders.

In keeping with the general track alignment, the bridge carrying the Poppenbüttel-Hamburg track had to be given a horizontal curvature of 540 m radius. The other bridge is straight (fig. 11). The space between the rails was, to a great extent, utilized for the top flange of the box girder system. Here, a flange plate of 1 052 mm width, 30 mm thickness at mid-span and 22 mm thickness at the ends of the bridge was fitted, which was supported on either side by 12 mm thick vertical plates welded to it. These plates were cold-folded by 90° with a rounding of 44 mm radius and form, further on, the supports of the welded wedge-shaped base plates of the rails (5). To these plates are welded, by means of fillet welds, the vertical web plates of the box girder system which are likewise 12 mm thick and which are, in their turn, connected by fillet welds to the 1 600 mm wide bottom flange plate. The box girders thus formed are stiffened by eight intermediate semi-frame type diaphragms, and two solid bulkheads at the ends. To avoid a reduction in the permissible compressive stress σ_D in the bottom flange plate, two flat bars 170/10 are welded by means of continuous longitudinal fillet welds to the inside of each bottom flange, and serve to take up the cross-welds for the connection of the semi-frame type diaphragms. Whether this measure is always effective in general application is a question which, on the strength of the latest knowledge derived from welding research, is justifiably doubted by renowned welding experts. Because of the low structural height available, Steel 52 had to be used for webs and flanges, whilst the diaphragms, footway corbels and gutter corbels consist of Steel 37-13. Rubber-sealed inspection holes are provided in the bottom flange at the ends of the bridge.

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(5) The plates correspond to design «Joarb 104*a*» of the Central Office of the German Federal Railway, Minden.

Design and appearance of the new bridge are illustrated in figures 12 to 15.

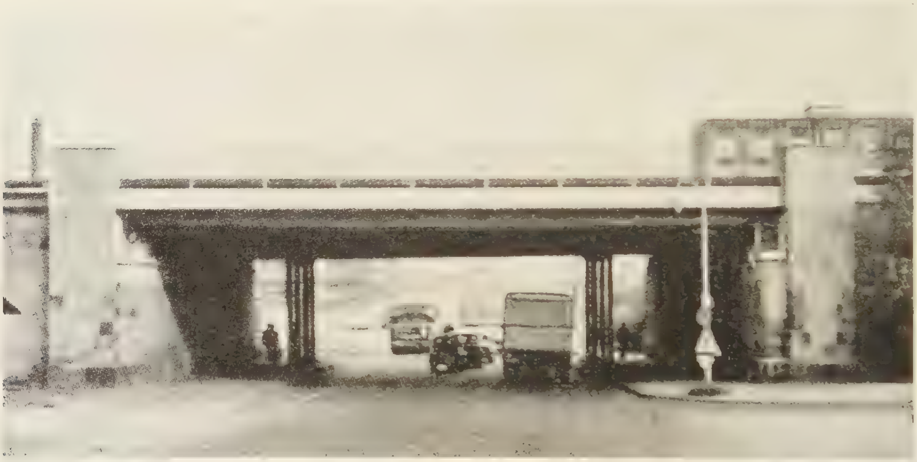

Fig. 12. — Bridge across Hammerbrookstrasse. New spans, without columns, in the foreground; old spans in the background.

III. The use of folded profiles.

The design provided for the use of 90°-folded plates of Steel 52 (Siemens Martin steel of high weldability) as part of the top flange of the box girder system. Just as the welding method came to be generally accepted thirty years ago, the use of cold-folded profiles for bearing structures is now becoming a widespread practice in steel construction. In lightweight steel construction, and for the construction of motor car frames, this practice has already been adopted long ago, and has been found fully satisfactory even where dynamic stresses are encountered. Folded profiles are aesthetically very satisfactory; they are also very economic as they offer many possibilities for varying the cross-section and making the most of the structural strength of the material and as they obviate the need for long welds.

In German railway bridge building, the use of folded profiles is a novelty, in view of the stipulations of the official directives of the German Federal Railway (6) : « Cold-folded plates may be produced by upright presses provided that the folds are moderate and, with low heights up to approx. 350 mm, in the straightening machine with low-set rollers or inserted wedges, provided that the folds are moderate ... ». It was therefore necessary to pay close attention to the proposed applications of the cold-folding technique to the top flange of this bridge.

In the case of the Hammerbrookstrasse bridge, the fold of the plate is 340 mm above the centre of gravity, in the compression zone of the cross-section. At this point, the stresses σ amount to $-$ 0.14 t/cm^2 for deadweight, and to $-$ 1.36 t/cm^2 for deadweight plus live load. In the vicinity of the fold, this plate, consisting of Steel 52, is thus only utilized to the extent of 65 % of the permissible stress. The fold, prepared in a special press, has a rounding radius of 44 mm, corresponding to 3.7 times the plate thickness.

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(6) « Technical Directives for Steel Structures », Regulations, No. 827 of the German Federal Railway.

During the folding process, the plate is pressed by the punch into the die and, by way of cold deformation, rounded at the desired radius. During the pressing, the degree of upsetting at the inner edge, i.e. the compressed edge, of the fold is small since a displacement of particles in this zone of the plate is largely prevented by the friction between the plate, and the press punch placed on it. In contrast, the plastic deformation of the particles on the opposite, tensile edge of the fold is much greater since, at that moment of the pressing process, contact between plate and die is confined to a small part of the rounding length.

As a result of this process which prevents major upsetting in the compression zone, the neutral line will shift from the centre of the plate nearer to the compressed edge. Press punch and die must therefore be well adapted to each other so that an unimpeded and continuous flow of material during the process is ensured. But also the material itself must conform to certain requirements. It must have a high ageing resistance if it is required, after the cold deformation of the folding process, to cope without deterioration with the fluctuating live load stresses. This condition can only be met by using killed steel where the requisite ageing resistance is ensured by the fine-grain structure. The plates used for this purpose must also be normalized.

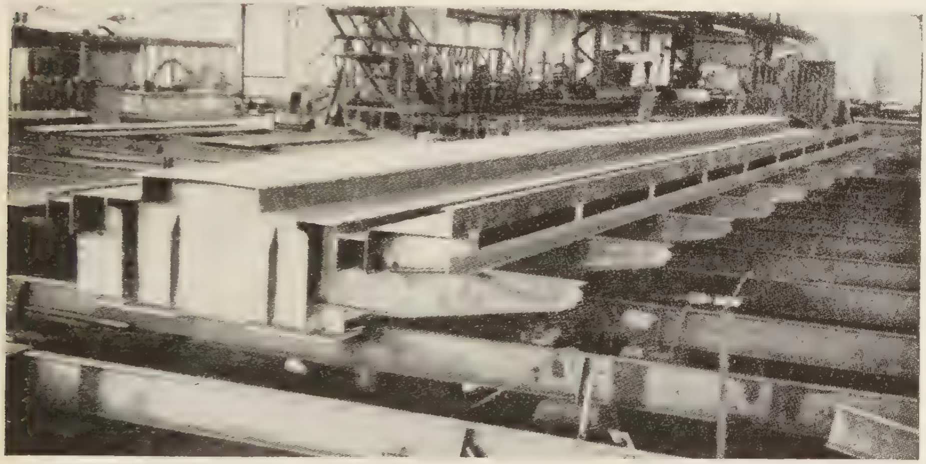


Fig. 13. — Main girder for the new bridge at Hammerbrookstrasse being prepared in the workshop.

During the folding, the plate is completely plastified on the compression side as well as on the tension side so that the stress will be constant throughout the plate thickness on either side of the neutral line, and will correspond to the yield limit. This stress is caused by the load introduced by the press punch. The internal stress moments are balanced by the external moments from the punch pressure. As soon as the punch is removed, the internal moments, now released, attempt to reverse the deformation. As with the relief of a tie bar which had been loaded beyond the yield limit, this restoration will be of purely elastic character. The stresses caused thereby will therefore show a linear increase from the neutral axis to the edges. Their distribution over the plate thickness will therefore differ from that of the constant yield stresses caused by the punch pressure. For that reason, the algebraic sum of both stresses can never become zero over the whole height of the cross-section.

After removal of the punch and after the subsequent minor elastic rebound of the rounding, there thus remains in the fold an inherent state of stress with alternating tensile and compressive stresses which are internally balanced. These residual stresses will take the form of compressive stresses on the plastically tensile side of the fold, and of tensile stresses on the plastically compressive side of the fold. The residual stresses act along the circumference of the fold, i.e. perpendicular to the longitudinal axis of the bridge, whilst the load stresses act in the longitudinal axis of the bridge. But the latter, due to the partially restrained transverse expansion, also cause stresses in the direction of the fold which are additive to the residual stresses. In the circumstances, it will never be possible, in the vicinity of the fold, to make full use of the material for the load stresses alone.

Moreover, experience has shown that any welds on the fold are liable to cause a considerable reduction in the bearing capacity of the material in this zone. It is therefore necessary to avoid welds in the vicinity of the fold.

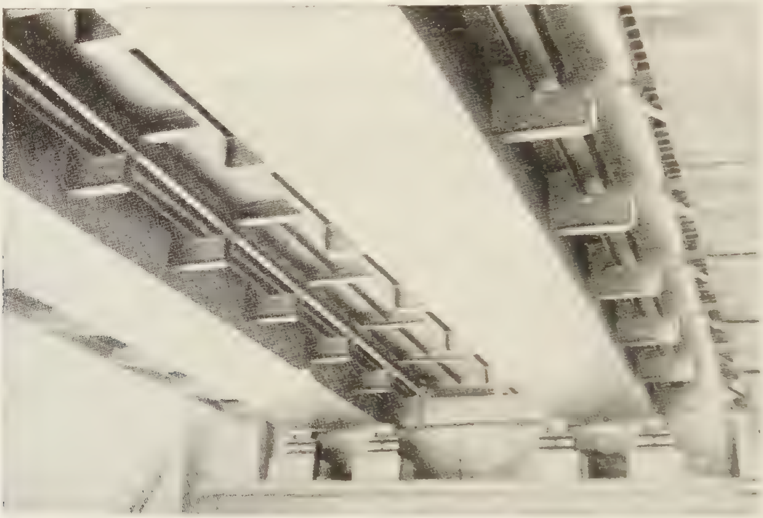


Fig. 14. — Underside view of the new bridge span across Hammerbrookstrasse.

The requirements can be summarized as follows :

1. Folded plates should only be produced from killed steel with fine-grain structure. The plates must be normalized.
2. The folding tools must be so shaped that the plastic flow of material can take place unimpeded and continuously without giving rise to visible upsetting phenomena on the compression side. The folding may therefore only be carried out at works where the process is fully understood, theoretically as well as practically, and where good modern tools are available.
3. Because of the residual stresses, the material must, in the vicinity of the fold, not be fully utilized for load stresses.

4. There must be no welds in the vicinity of the fold.

Owing to the use of folded plates, the cross-section of the bridge across Hammerbrookstrasse represents a structurally and economically favourable solution. If it is, moreover, considered that all the folds are located in the compressive zone which is less sensitive from a fatigue strength point of view, and that they are merely subjected to unidirectional fluctuating stresses, and not to alternating stresses, there are, in this case, no technical objections against the use of folded plates provided that they are manufactured in conformity with the conditions listed above. It may be mentioned in passing that the range of stress fluctuation in this bridge, which is designed for loading diagram S but is normally only used by the lighter electric suburban trains, is smaller than is assumed in the relevant official specifications. If it is intended, in future, to place the fold at a zone subjected to higher stresses than those encountered at Hammerbrookstrasse, it will be necessary, especially with tensile stresses, to clarify experimentally the limit up to which the material can be subjected to load stresses.

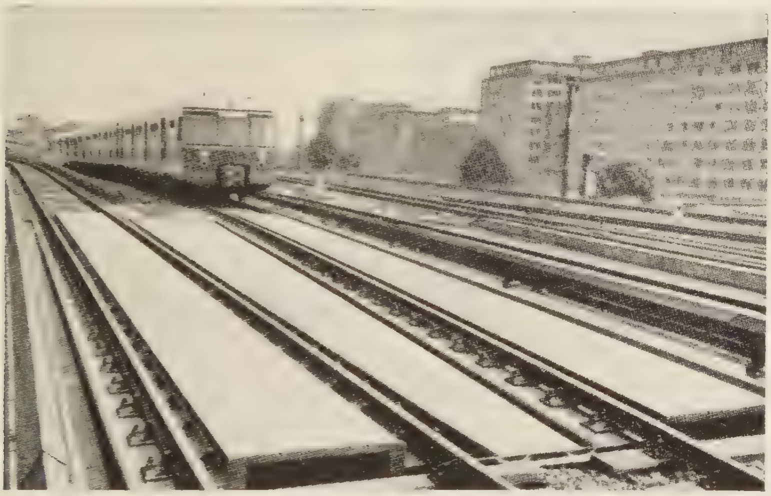


Fig. 15. — New spans of Hammerbrookstrasse bridge for suburban tracks.

IV. Behaviour of the bridge under traffic.

Because of the special design adopted for the cross-section, it appeared necessary to verify the behaviour of the structure under traffic. The tests were carried out with two three-axled testing cars with precisely known axle loads and wheelbase. One of these vehicles had the extremely heavy weight of 10.9 t/m, whilst the other weighed 9.15 t/m. These tests were intended to show whether, in accordance with the assumptions on which the calculations had been based :

1. the stress distribution is linear over the height and width of the load-bearing cross-section;
2. the maximum principal stresses in a critical cross-section remain within the permissible limits, with special regard to the folds in the cover plate;
3. the stiffeners are so effective that no deformations endangering the stability of the box girder are encountered.

Finally, it was intended to find out whether :

4. it is possible to ascertain the magnitude of

the active contribution of these parts of the cover plate (drain gutter) which are some distance away from the box girder proper and have been neglected in the calculation.

The tests carried out with the bridge testing train of the Central Office of the German Federal Railway, Munich, confirmed the expected performance of the bridge in all respects. Even at the folds, to which special attention was paid, the principal stresses remained within the magnitude of the stresses in the longitudinal direction of the bridge, calculated by conventional methods of stress analysis. This also applied when the vertical traffic load was supplemented by a horizontal load (transverse shock, and centrifugal force).

V. Economic assessment of the solution adopted.

The economic success of the solution adopted for the bridge across Hammerbrookstrasse is clearly demonstrated by the fact that the steel weight and price, exclusive of erection, of the main girder alone, as stated in the tender, was 0.888 t/m and DM 1 500/t, respectively, compared with 1.47 t/m and DM 1 700 in the next lowest tender. In the course of the further design work, the weight of the 18.56 m long main girders alone had to be increased to 0.963 t/m. If the footway and railing on one side are added, the weight amounts to 1.18 t m. With the cable conduit beam and bearing, finally, the total weight adds up to 1.58 t m.

If the new bridge is compared with the old one, built about fifty years ago (fig. 16), the first obvious advantage is the improvement of the roadway through elimination of the intermediate supports. Admittedly, however, this advantage can not yet be utilized to the full, as the three old bridges with intermediate supports, carrying the adjacent tracks, continue to be in existence for the time being.

But the progress achieved in steel bridge construction is demonstrated most strikingly by the reduction in weight. Whilst the old structure, with footway and columns, weighed 30.5 t, yet was only able to carry trains corresponding to loading diagram G (20 t axle load; 8.18 t/m), the new bridge weighs no more than 22 t but is able to carry trains of loading diagram S (25 t axle load; 10.4 t/m).

One disadvantage of the new structure is the weight of the bearings which are several times heavier than the simple friction

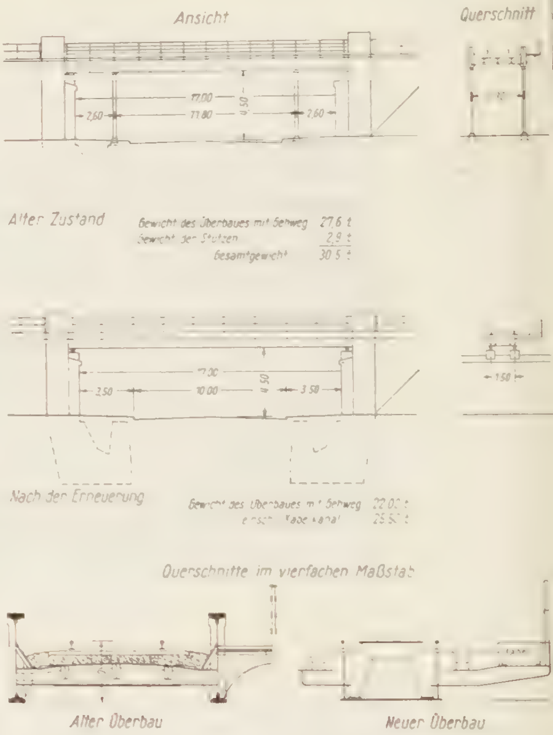

Ansicht
Querschnitt
17.00
17.80
2.60
2.60
Alter Zustand
Gewicht des Überbaues mit Gehweg 27,6 t
Gewicht der Stützen 2,9 t
Gesamtgewicht 30,5 t
17.00
2.50
10.00
3.50
4.50
1.50
Nach der Erneuerung
Gewicht des Überbaues mit Gehweg 22,0 t
einschl. Kabelkanal 25,5 t
Querschnitte im vierfachen Maßstab
Alter Überbau
Neuer Überbau

Fig. 16. — Comparison of old and new bridge spans at Hammerbrookstrasse.

Old condition :

Weight of superstructure, with footway	27.6 t
Weight of columns	2.9 t
Total weight	30.5 t

After reconstruction :

Weight of superstructure, with footway	22.0 t
Total weight, including cable conduit .	25.5 t

N.B. — Ansicht = elevation. — Querschnitt = cross-section. — Querschnitte im vierfachen Masstab = cross-section on a four times enlarged scale. — Alter Überbau = old superstructure. — Neuer Überbau = new superstructure.

bearings of the earlier bridge which were regarded as adequate at the time.

Admittedly, the weight comparison is not quite conclusive because of the elimination of the ballast. The noise caused by the train on the steel structure with rubber-supported rails will call for some further expenditure with a view to noise abatement. Experience at this bridge as well as at all other bridges with rubber-supported rails without ballast suggests that the applicability of this type of steel bridge design is likely to be economically limited by the expenditure to be incurred for noise abatement.

D. CONCLUSIONS

The civil engineering works at and near Berliner Tor station, required for the extension of electric suburban services to Bergedorf, were commenced in the autumn of 1957, and were completed in the autumn of 1959 in good time for the commencement, on the timetable change-over date of 4th October, of normal services over the reconstructed bridges. This was the best award for the successful efforts made by all concerned.

The prestressed bridge at Berliner Tor station was designed and supplied by Dortmunder Union. Design and construction of the bridge across Hammerbrookstrasse were entrusted to the Rheinstahl - Eggers - Kehrhahn steel works, Hamburg. In both cases, valuable ideas were contributed by Professor Pelikan of Stuttgart Technical University who acted as consultant. The author is also especially indebted to his colleague, Mr. Knebel, Chief technical inspector.

[**656** .25 (73)]

Report on automatic train operation,

by F. George, General Railway Signal Co.

(From the Signal Section Proceedings of the Association of American Railroads, Vol. LVII, No. 2; Minutes of the Sixty-first Annual Meeting, Chicago Ill., October 11, 12 and 13, 1960.)

Automatic train operation is just another form of « automation », and « automation » is today synonymous with our concept of modern industry. The word itself, « automation », appeared about 1949. I mention this simply to place emphasis on the fact that railway signaling has employed automation many years, perhaps the most common form being the automatic interlockings which have displaced manually operated ones. We could just as well have said during the past thirty-odd years that we were « automating interlockers », instead of saying « installing automatic interlockers ».

General Railway Signal Company's experience and contribution to the art of automating the operation of motive power has been by degrees. As the old saying is, « It is better that we walk before we run ». So it has been in this line of endeavor.

To start with, many of the basic tools applicable to automating operation of locomotives, and trains if you will, have been in use for many years. Train control, coded track circuits, cab signals, speed control, remote supervisory control systems, and the component parts that make up such systems, dependable safe relays, coding equipment, governors, and many others. These are the basic tools.

Above all else in importance, the quality that must be incorporated into automatic train operation is « safety ». Railroad signal departments have trained themselves in, and practiced the art of, safe design and operation, including the « closed circuit principle of operation ». So, it seems to me quite natural, and it makes good sense, that the signal companies and the signal departments should contribute to the thinking going into the development of automatic train operation. For this reason, I am most grateful of being accorded the privilege of bringing this subject before you here today.

At GRS, the beginning of motive power automation was in 1957. At that time, we furnished a battery-operated mine locomotive equipped for remote control. The control was by an operator viewing the operation, and directing via inductive carrier. The controls provided were forward, reverse and stop, with brakes applied at stop and at any time the carrier should fail to be received by the locomotive.

Then, in 1958, the remote control of a Diesel locomotive was discussed with the Quebec North Shore & Labrador Ry. With their cooperation, the system, also employing inductive carrier control, was developed and the equipment installed, tested, and placed in service on a Diesel locomotive used in a gravel pit on their lines. Its work there is of a repetitious nature, hauling loads of gravel to a dumper, dumping the loads one by one, and returning the same empty cars to the shovel, where they are loaded, one by one. The system also included the dumping controls, the cars being pneumatic dumpers.

Also in 1958, at the suggestion of the Quebec North Shore & Labrador Ry. and their associates, an informal symposium was held at Sept Isles, Quebec. Operating officials from a number of railroads participated in discussions concerning how railroads would, and could, be operated in the future. The conclusion was that automation of more railroad operations, including operation of trains, would have to come eventually if railroads are to survive as the mainstay of mass land transportation.

In late 1958, the New York City Transit

Authority presented a challenge to the industry, asking what could be offered in the matter of applying automation to their operation.

The General Railway Signal Co., along with the Union Switch & Signal Co., both with the collaboration of Westinghouse Air Brake Co. and the Car and Signal Departments of the Transit Authority, accepted the challenge. The rules laid down by the Transit Authority were that we could do it anyway we liked, as long as the systems produced by the two signal companies were safe, and were compatible; that is, a GRS equipped train could run over a US & S equipped track, or vice versa.

The operation proposed for this automation project was the Shuttle Line, where trains run back and forth, each on its own track, between Grand Central and Times Square stations. This operation has to be ultra-safe, and dependable — it carries passengers. To accomplish this, we found ourselves back to the track circuit. Track circuits of carefully determined length, on which rate codes are employed to transmit the wayside to train commands, were set up on a test track simulating the Shuttle Line. Here, since early this year, a three-car train comprised of MU type subway cars, has been given its « shakedown » tests. Its operation is programmed, as would be required in the Shuttle. Operation of throttle, air brakes, dynamic brakes, car doors and train sign changes, are all automated. Time will not permit describing here the safety checks incorporated into this system, and working very well, but I cannot help commenting on the requisite that station stops must be accomplished within plus or minus 5 feet of a given point. It is being very well met, with feet, not inches, to spare. And this with load and no-load train conditions. Work is now underway to move this train into the Shuttle, onto an assigned track.

The Canadian National Rys. Research Department, recognizing the importance of maintaining a progressive approach to the future operation of railways, had also given thought to how operation of trains might be automated, and early in 1959 issued a report entitled « Automatic Operation of Trains — Logic of Alternate Methods ».

In their analysis of the problem, they arrived at certain conclusions, for example, that :

1) continuous, not intermittent, control would be required;

2) radio, or lineside induction control, would not provide the degree of protection against control errors and wayside abnormalities; nor properly interlock and direct controls to trains at specific places, as would continuous communication via the rails themselves;

3) track circuits would provide continuous train control and cab signals, and could be integrated with the supervisory control of CTC;

4) the system should be able to provide situation « reports »;

5) directing of trains from a central brain would be preferable. Supervisory controls would originate there, and be monitored and checked enroute to trains;

6) locomotive intelligence — only that required to properly interpret controls received, and self-check train and locomotive conditions, is all that would be required on the train;

7) the central brain would eliminate duplication of intelligence equipment on many locomotives.

It stands, therefore, that the necessary facilities can be provided by conventional CTC, with minor additions at the central office, and with rearrangement and additions in local field equipment, plus the locomotive equipment. Also, with proper signaling, conventional trains can be operated over the line, interspersed with ATO trains, if desired.

In July 1959, a meeting instigated by Mr. J. W. Buford of The Hanna Mining Co., was held in Montreal. This was attended by representatives of interested railroads, General Motors Diesel Limited of Canada, and myself as representative of General Railway Signal Co.

At this meeting a committee was formed and charged with the task of producing specifications, both as regards operation and the equipment required to cover application of automatic train operation; ATO as it had now become called, to a specific piece of railroad: namely, the Carol Lake Ry., a line approximately 40 miles long, then under construction branching off from the Quebec North Shore & Labrador Ry. at their mileage 224.

Some preliminary operating requisites, furnished by the Quebec North Shore & Labrador, defined the trains under consideration as ore trains comprised of approximately 125 cars, about 11 000 net short tons, to be powered by four 1 750 HP Diesel locomotives.

At this point, the Air Brake Division of Westinghouse Air Brake Co. was invited, and accepted the invitation, to participate in the project. So now we had a team comprised of interested railroads, General Motors Diesel Ltd., Westinghouse Air Brake Co. and General Railway Signal Co.

Engineering consultations followed, and each of the three supply companies determined and assumed responsibility for that part of the system peculiar to their normal line of endeavor. The locomotive manufacturer produced the necessary direct propulsion and dynamic brake controls, along with the required interlocks and safeguards of engine operation. The air brake people, the control and operation of air brakes which, under certain conditions, must be integrated with the control of dynamic brakes, all of which must, of course, be properly checked and interlocked with other engine and train operating functions. The General Railway Signal Co. produced the primary control sensing equipment required on the locomotive, that is, that equipment which receives messages from the wayside, analyzes them, and after comparing with actual train performance, formulates specific train operation commands to be acted upon by the engine and brake control systems as required.

For purpose of the tests, no wayside supervisory control and control coding equipment was installed. Instead, the desired codes were generated by equipment carried on the locomotive, and applied inductively to the locomotive receivers of the control sensing equipment. We did provide wayside grade and slow-order markers comprised of inert tuned coils.

Each of the three companies built their own « package » so to speak. The Canadian National Rys. cooperated by making available one of their 1 750 HP GR 17 z Diesel locomotive units. It was modified as required, the equipment installed and then shop and yard track tested at the GMD, London, Ontario, works.

Following that, the Canadian National made available ten or so miles of main track in the vicinity of London, Ontario, and provided a train, a train crew, and necessary running rights as required. With this contribution, tests of automatic operation of a Diesel-powered freight train began early this past summer.

An exhausting test program was set up, simulating all conceivable operating conditions. The terrain of the line where the tests were conducted contained enough grade at one point to provide reasonable grade operating conditions, both as pertains to ascent and descent. For most of the testing, the test train was comprised of about 35 cars, some loads, some empties, with a gross tonnage of about 2 000 tons, which closely approximated the tonnage rating of this type of locomotive on this line.

Our testing was concluded by making runs on a section of track having a descending grade of about .9 to 1 %, for a distance of approximately 9 miles. For these runs, the equipped locomotive was MU coupled to another, standard, Diesel-electric locomotive — no special connections of any kind were required in the coupling. We had, for one run, a train of about 6 600 tons, comprised of 76 cars. The equipped locomotive was in control, and it automatically handled the train to everyone's satisfaction, including down the grade where both air and dynamic braking were required to properly control the speed of the train.

The system tested here was not sophisticated to the degree we know it can be — we were after information and experience on the more basic problems of automatic train operation — answers to which would enable us to obtain optimum train handling. All of us learned much regarding these matters, and I dare say, found reason to have a lot of respect for the engineman who is capable of smoothly and accurately starting and stopping a long train under varying conditions of grade, rail, and train slack and brake response. But these conditions can be determined, and the operation programmed accordingly, so that optimum train handling may be obtained. I think we have accomplished much toward this end.

Time will not permit me at this point to go into more detail regarding the automatic equipment and how it works — I wish I could, but with the thought that pictures tell more of a story than words, we will show you here in a moment, some brief movie shots of the three automation projects I have spoken of, the gravel pit Diesel, the subway test train, and the Diesel-powered freight train.

I do want to say, before you see the movie, that we at General Railway Signal do not pretend to say we have acquired all the best answers to the problems we know are involved in automatic train operation, but we can, now, present factual views of the first steps in railway automation — we are beyond the stage of just talking and writing. We are continuing research and development of better, more sophisticated control systems and equipment. But that is going to require time, experience, and money.

[**656** .225 (73)]

Containerization.

An AREA Report of developments in new methods and modes of transport.

(*From the American Railway Engineering Association-Bulletin*, November 1960.)

The origins of containerization in the United States can be traced to the early nineteenth century. It was not until the 1920's however, that American railroads employed containers to move any significant part of their traffic on a routine basis. This early rail-sponsored program failed to be a success for several principal reasons. First, the carriers involved were not permitted by the Interstate Commerce Commission to publish rates sufficiently attractive to generate necessary amounts of container traffic notwithstanding the fact that the rates which some of the railroads proposed were certainly compensatory when measured against any known yardstick of costs. Second, the rail carriers' concept of containerization at that time did not include their adopting a « systems approach » to the problem. There was little recognition of the interrelationship between decisions taken in one area of containerization and those reached in the functioning of the system in another of its elements. Third, rail carriers interested in containerization worked almost entirely independently of one another, viewing container traffic primarily as local traffic with a relatively small amount of the total container movements actually involving interchange. As a result, no serious attempts were made towards industrywide container standardization.

This all happened in the past. But obviously, a number of lessons can be learned from this earlier railroad experience. It is important that such experiences be assimilated by the railroads because the present marked trend towards containerization, coupled with the economy's demand for new services of this type, present the railroads with an opportunity to re-establish themselves in a position of growth and to permit the industry to continue in the long-run to function as the nation's principal agency of transportation.

Some very significant recent developments have occurred which put the movement of containers in a different light. These developments can be likened to the impetus given to the long-haul intercity trucking operations by adoption of the king pin and fifth wheel combination which enabled trailers and truck tractors to be coupled in any combination anywhere in the country. This did for the trucking industry what the standardized coupler did for the railroad industry.

The container is, in a way, a further development of the highway trailer. It is therefore not surprising that container-on-flat-car operations are following closely on the heels of the trailer-on-flat-car development. In fact, two railroads, the Missouri Pacific and the New York Central, make container units a substantial part of their road-rail operation.

The Missouri Pacific uses demountable trailer bodies as containers, transferring them by overhead gantry crane from trailer chassis to railroad flat cars. It has 413 such units and is also interchanging containers with the Baltimore & Ohio, which has 150 similar containers. The New York Central uses in its Flexi-Van service a special demountable trailer unit that rolls onto single-purpose flat cars and is transported by rail without trailer running gear. The New York Central has 1 075 such units. It interchanges with the Milwaukee, Burlington, and Santa-Fe, extending this type of service coast to coast. The Milwaukee

Road has 325 Flexi-Van container units and the Burlington 100.

Both of these methods of transportation were evolved out of a desire to eliminate the need for transporting trailer chassis along with the trailer body.

Piggyback transport itself has proved to be an effective means of combining rail and truck operations; the container development is becoming a further extension of that. As such it holds great potential for effectively extending the service range of railroads to points beyond present rail lines.

Containerization, as implied above, means more than merely placing commodities in a container. It is a method of transportation and distribution involving not only the container but also the methods of handling, of accounting and control and the publication of scales of rates and charges associated with container use. It is a whole set of problems; the ramifications of decisions in any single problem area must be understood in terms of the impact on all other aspects of the overall system.

This report deals with van containers and cargo containers. Such containers are defined as having a base area in excess of 64 sq. ft., and they can be moved with equal facility by any of several modes of transportation — rail, highway and water. While the highway semi-trailer or trailer is a container and while some of the best aspects of containerization are demonstrated by present, trailer-on-flat-car operations, little consideration will be given here to such « containers » to which wheels are permanently attached.

The growth of containerization in the United States can be illustrated by the fact that in the course of a research project on containerization conducted at the University of California at Los Angeles in 1955, it was determined that, aside from the military establishment, there was then no systematic and regular use of containers for shipment of general commodities in the United States. By contrast, in mid-1960 it has been determined that there are in the neighborhood of 50 000 general commodity and refrigerated containers owned and operated by American carriers of various kinds. The great majority of these containers — some 41 000 — are owned by marine operators, but in many instances these containers move inland for traffic. Present rail ownership of general commodity and refrigerated containers approximates 3 000 units, many of which are restricted to carrying traffic local to the owning carrier's lines due largely to the general lack of container standardization.

What are the *advantages of containerization ?*

1) Widespread use of containers will reduce the cost, time, and labor required for loading, stowing, and unloading.

2) The monetary costs and delays incurred in handling separate shipments at transfer points can largely be avoided. This, of course, is at the heart of the « unit loading » principle which is one of the primary bases for the economies of containerization.

3) The greater speed with which loading and unloading operations can be performed increases transport vehicle utilization, thus minimizing the capital investment in such equipment which is necessary to produce any given amount of transportation.

4) In the same vein, the more uniform loading and unloading times which containerization produces makes possible more precise scheduling of the transportation vehicles involved.

5) Containerization substantially lowers packaging costs and packaging material requirements; physical damage, breakage and pilferage are also reduced.

6) Use of containers minimizes paper work for many types of moves.

7) Containers provide shippers and receivers alike with more flexible and responsive transportation, permitting receipt and dispersement of commodities to be scheduled more in keeping with the customer's other operations. In this connection, containers can provide covered storage capacity in open areas when there is emergency need

for it. It can be said that containerization is more « consumer oriented » than most of the services offered by the rail carriers. Such reorientation of railroad practices is long overdue, and containerization has the added advantage of fostering the change.

Reliance on containers may also carry with it somes significant *disadvantages.*

1) The capital cost of the containers themselves and of other components of the container system are substantial, although they may be less than the alternative means of accommodating the traffic.

2) The tare weight of the containers may exceed the tare associated with shipping in another manner, although again this will often work the other way.

3) The need for returning empty containers where there are traffic imbalances may add to the cost of producing transportation with a container system. This depends upon the magnitude of the empty return problem where some other means of handling the traffic could be utilized.

4) The problem of accounting for containers will be enormous and is aggravated by their ability to be detached from basic transport vehicles; in addition, the number of containers needed to provide a given transport capability may be substantially greater than the number of present-day transport vehicles required. This again adds to the accounting problem. (Without doubt automation of the overall container accounting task is important, and if accomplished, it is possible that container accounting may be substantially simpler and less costly than is the present car accounting job.)

5) Maximum employment of containers requires computation and publication of new scales of rates and charges involving both inter-carrier and inter-modal interchange; this will require the expenditure of substantial amounts of time, effort, and money but should prove a sound, profitable investment.

For the railroads to derive maximum profits from the present trend towards containerization, it is obvious that substantial standardization is essential in virtually all elements of the container system. Without such standardization, interchange will be minimized, and the full benefits of containerization will be denied to the economy in general and the railroad industry in particular.

A number of organizations in the recent past have devoted themselves to the problem of *container standardization.* Preeminent among these has been the « MH-5 » committee on shipping containers of the American Standards Association. Fortunately, this committee has representatives of every mode and virtually every method of transportation, with competent persons representing the viewpoints of shippers, carriers, and equipment manufacturers alike. Most important, the work of the MH-5 committee, although more advanced than most organizations interested in container standardization, is yielding the same general conclusions which other committees and groups are reaching.

In surveying the reports of the various container standardization groups as well as other material pertaining to containerization, a number of general conclusions with respect to container size can be drawn. First of all, it seems clear that a container cross section of 8 ft. by 8 ft. will be adopted as standard. As to lengths, the standard containers will be found in three sizes : 10, 20 and 40 ft. To some extent, length, width, and height requirements are dictated by the capabilities of existing transportation equipment and rights-of-way. Each mode of transport and many individual carriers will have contributed to the compromises necessary to achieve standardization of dimensions. Given containers of the three standard sizes, there is a general feeling that greatest emphasis will be placed on procurement of containers of the smaller two sizes with the use of 40-ft. units being somewhat restricted to movements between major terminal areas which do not require the container to be moved through a congested central city area in the course of its travels.

The most common *container construction material* is steel which, of course, represents at present the medium for producing the lowest cost and most durable reusable shipping container. There are a number of aluminium and steel-and-aluminium containers in use, but while they reduce the weight of a container of given capacity, such construction presently incurs substantially higher capital cost. As experimentation and development continue, other materials may come into widespread use in container construction. These could include plastics, magnesium alloys and other materials used separately or in various combinations.

Among the questions which must be considered in determining the materials to be employed in container construction are: How rigid and dimensionally stable must the container be? How much of a load, both statically and dynamically must it be capable of sustaining? How durable should it be; how long should it last? What corrosion or other environmental problems are anticipated? As noted, steel provides the best solution at present, but any steps toward container standardization should not eliminate the possibility of integrating into the system containers of standard dimensions which are constructed of other materials than steel.

Many of the *container design features* which should be standardized are dictated by the standard container handling techniques adopted. Others are determined by the character of the commodities which the containers are intended to accommodate. In the former category, it is clear that every container should be fitted with the hardware necessary to permit its being lifted from above. All containers therefore must have corner castings designed for this purpose. The 40-ft. containers should also have similar fittings on both top edges, 10 ft. in from each end. Every standard container should also be capable of bottom-lift handling by fork truck or by strap or grappler lift from above. The standard container must be corner post loaded and stackable at least two high when loaded and somewhat higher when empty. If the container is to have the capability of free interchange with ocean carriers, it should be able to withstand stacking at least six high when loaded. Given present construction techniques and container loading concepts, the standard container will probably have a door on one or both ends rather than along its sides.

With respect to the *terminal handling of containers*, vehicle-to-vehicle or vehicle-to-ground transfer of containers can efficiently be carried out in several ways, depending primarily on the number of handlings which the particular terminal is required to carry out in any given period. While the argument between the end loading and selective side loading of railroad cars rages on with respect to piggyback terminal operations, selective side loading is proving to be best suited for incorporation into the container system. Presently, for major terminals where the number of transfers is substantial, the most favorable way of handling the containers is by top lift. This dictates the use of a device such as the track-straddling gantry crane. This piece of handling equipment presently effects train-truck or train-ground transfer more efficiently than any alternative method, provided there is sufficient traffic to keep the gantry busy. As for the gantry itself, it should be capable of employing the appropriate method of lift as dictated by the job to be done.

At terminals with less container activity it is imperative that a handling device of substantially less capital cost than the track-straddling gantry be employed. As yet no such piece of equipment has been developed, but a number of manufacturers are busily engaged in trying to solve this problem. It should be noted that one of the reasons the standard container must be designed to accommodate bottom-lift techniques is that it is probable that the low-cost container transfer unit for smaller terminals will use such a technique.

A variety of *railroad equipment* now in service is capable of handling containers in its present form or with some modifications. While some of the rolling stock will accommodate only specially designed containers, other cars will take virtually any type of container. This equipment includes flat cars of lengths ranging from 18 to 85 ft., gondola cars, Clejan type of equipment, Flexi-Van cars, etc. In the past several years there has been a marked trend towards the procurement of flat cars 85 ft. in length. Several thousand of these are presently in service with many more on order. These cars can accommodate standard containers in various combinations to a total of about 80 ft. of length. Most of these 85-ft. flatcars, however, require substantial modification if used in container service and if a satisfactory ride is to be given to the container and its lading. Several equipment manufacturers are presently offering devices which will improve the ride qualities of such rail equipment when used with containers rather than with the highway semi-trailers for which they are primarily designed.

It is important to note that several railway equipment manufacturers are actively developing new types of cars to accommodate containers. One of the common objectives of these development projects is to minimize the capital cost of the rail component of the container system; other objectives include the reduction of car maintenance costs and the improvement of the suspension systems to provide the container and its lading with the most « delicate » possible ride.

It is quite possible that the most crucial single factor which will govern the rate of growth and development of containerization is that associated with the *rates and charges published for container services.* Not only the level of rates but their form of publication will be extremely important. For example, the existence of a large number of joint, through rates which permit handling of containers by more than one carrier and by more than one mode will cause marked expansion in the demand for container services in and of itself. With respect to the level of rates applicable to container movements, experience so far indicates that there is considerable price elasticity in the demand for container service. It will be up to the carriers and the commissions to determine the type of rates which will be published as well as the level of such rates.

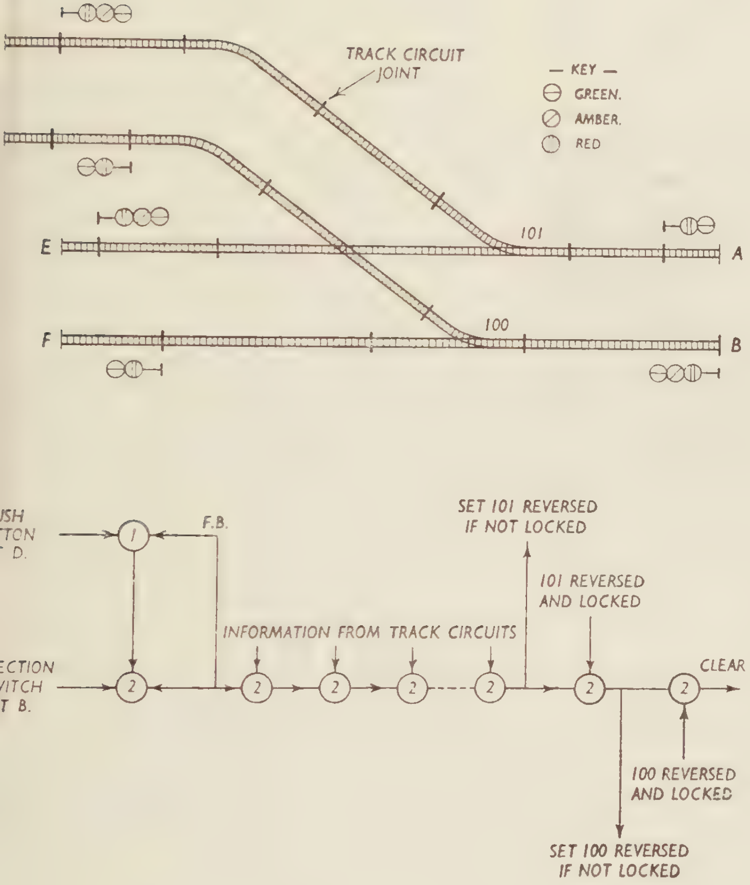
It is imperative that carriers and regulatory agencies alike recognize the importance of appropriate rates and charges to the growth and development of the container system. While minimum diversion of traffic from highly rated and profitable categories is a laudable objective, it is also necessary to recognize that such diversion will have to be tolerated to some extent if the container system is to grow and develop and produce its full potential in savings and profits to carriers, shippers and the public.

With respect to *financing*, it is entirely possible that the railroad industry as a whole or major segments of it will find it advantageous to procure and operate substantial pools of containers. Such an approach has already become an important contribution to T-O-F-C development. Pool arrangements would increase the possibility of container traffic being freely accepted in interchange in the early stages of the container system's operation. Also, a pool operating under a single manager for movements control, should minimize the extent to which containers have to be back hauled empty. In addition, if a large enough container pool is established by the railroads, and if this pool employs containers of the standard configuration, great impetus will be imparted to the whole container standardization program. Thus, the container development can become a method of transportation that will prove extremely beneficial to the railroads. It holds the potential of becoming the first common denominator of the various modes of transportation. And with the railroads retaining an « inherent advantage » in the area of line-haul transportation, they will be able to enlarge their share of the transportation market as they participate in this pattern of positive, dynamic growth.

[656 .25 (42)]

Electronic railway-signal interlocking.

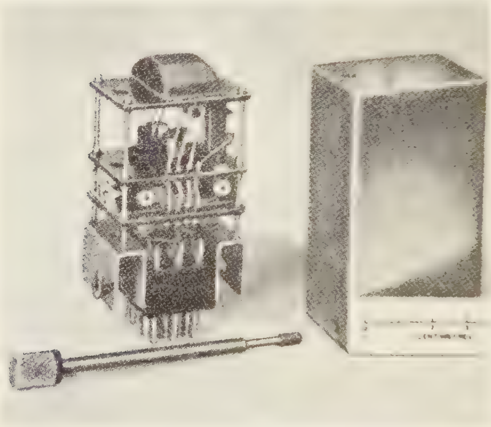
(*The Engineer*, December 16, 1960.)



Model track and simplified diagram of electronic signal interlocking system

An installation, which is believed to be the first electronically-operated system of railway-signal interlocking in the world, is to be carried out in the branch-line signalbox at Henley-on-Thames, Western Region, British Railways. The new system has already completed its laboratory trials and, when it is installed at Henley in the early summer of next year, it will be subjected to full-scale trials. It has been developed by Mullard Equipment, Ltd., under contract to the British Transport Commission.

It will be recalled that electronic systems have already been applied to the remote control and indicating elements in some signalboxes on British Railways. These elements have important operational functions in the signalling system but their contribution to overall safety ultimately depends upon effective interlocking of the signals and points. Hitherto signal interlocking has been effected either by mechanical locks or, in more modern installations, by electromagnetic relays. In the Henley installation these components will be replaced by electronic units incorporating transistors, semiconductor diodes and ferrite cores.



Transistorised plug-in logic unit for system of electronic railway-signal interlocking.

The hoped-for gain by the adoption of electronic circuitry is that the absence of moving parts may presage substantial savings in maintenance costs. This means that electronic interlocking will be justified for future signalling schemes, provided that it can surpass the reliability of magnetic relays which (as pointed out by the British Transport Commission) can operate for at least five years in a sealed box and have a failure rate of only one in thousands of millions of operations.

A working model of a double junction, completely controlled by the new electronic system, was demonstrated by Mullard Equipment, Ltd., at Mullard House, Torrington Place, London, W. C. 1. The model used for this demonstration is illustrated diagrammatically below. It operates on the conventional « entrance-exit switch and push-button » system and is provided with track and point indication; the only relays used are track relays, Post Office type relays being used for convenience.

To set up a route on the model, in the direction *B* to *D* for instance (see diagram), the direction switch at *B* is set to direction *B* to *F* and the exit button at *D* is pressed. This action results in the points 100 and 101 being moved to the reverse position. These points are interlocked and the sequence is that 101 is reversed first and when it has been detected as being reversed, the points 100 are reversed. However, this route *B* to *D* can only be called provided that the information from the track circuits involved indicates that there is no vehicle on the track and also that the points are not locked — that is to say, that a prior route has not been set up along, for instance, *E* to *A*.

A simplified example of a sequence of events is shown in the lower diagram. The pulses from the push button at *D* are fed to an « Or » gate which sets up a feedback path to maintain the circuit. The output from the « Or » gate is fed, together with the signal from the switch at *B*, to the « And » gate which then — and only then — gives an output to the first track circuit « And » gate. This input together with the input from the track circuit (providing the latter is clear) will result in an output to the next track circuit « And » gate and so on. After all the track circuits have given the information that they are unoccupied, the points 101 are reversed, providing they are not locked, and the signal from the track circuits together with the information that 101 is now reversed and locked is fed to another « And » gate. The points 100 are now reversed and locked, and this information, together with the output from the last « And » gate, is fed to the final « And » gate, the output of which clears the signal at *B* (see diagram).

It is a logical process and if for any reason the required information does not reach any one of the « And » gates in the chain the sequence will be broken and the route will not be cleared. When a route has been cleared and a train travelling in the direction *B* to *D*, for example, has passed over the first track circuit in the route, the signal is automatically returned to red. Although the direction switch is still set, this route cannot be used again, by pressing the exit button, until the whole sequence of calling has been repeated.

In addition to the interlocking of the points and the use of track circuits, there is also a device whereby if a signalman has set up a wrong route (*B* to *F*, instead of *B* to *D*, for instance) he is unable to reset the route immediately if a train has already entered the approach track circuits. He can, however, set all the signals to red, and after a suitable time delay to allow the train to stop the route can be reset. Obviously if this device were not included a signalman would be able to reverse the 100 points, which may not complete their movement before the train reached them and thus cause a derailment. The logic system can therefore provide an antipreselection device and an approach locking device to meet signalling requirements.

Track circuits of the normal type are used. The electronic logic units from which the system is constructed are plug-in units. They are designed to operate safely in ambient temperatures between — 20° and + 50° C; Mullard transistors, semiconductor diodes and ferrite cores are used.

A typical electronic logic unit is illustrated here, the components being mounted on a stack of insulating wafers. The uppermost component in this case is an encapsulated ferrite core. In a practical signal interlocking installation, five different types of these logic units would be required. In physical layout they are all similar. Each is protected by a rectangular casing of anodised aluminium which is colour-coded for identification. These units are mounted in racks and test sockets are provided for servicing, which is based on the identification and replacement of a faulty unit. It is emphasised by the manufacturer that the system is designed to « fail to safety » and that this condition has been applied to the logic units individually and collectively.

[656 .212 (44)]

Checking parcels by radio-electric link at Lille-Saint-Sauveur.

(*La Vie du Rail*, 23rd October 1960.)

The required infrastructure for radio-electric links being completed and the technical tests having proved satisfactory, the installation was handed over at the beginning of April 1958.

After a short period of instruction during which the staff was initiated into the working of the equipment, the organisation that had been carefully studied for several months, was set up and the changeover from the classic method of checking to radio checking took place during the night of the 9/10th April, without any intermediate phase.

The whole of the organisation of the checking of the parcels traffic had been studied as a function of this method.

DESCRIPTION OF THE INSTALLATION.

Arrival depot.

Parcels traffic for zone 2 Lille, i.e. Lille and its immediate suburbs, are unloaded in the Arrival Depot, which consists in fact of a single shed, about 400 m long, divided up by fire-break partitions, with sufficient openings to allow of free circulation from end to end.

The traffic office with its control boxes and special files.

The unloading points are situated towards the centre of the shed; the parcels are sorted as they are unloaded and taken to the 28 bays. These bays correspond in most cases to one of the routes taken by the haulier responsible for delivering them to destination. The others are for parcels to the satellite stations which are served by road from Saint-Sauveur, or for certain important clients.

A checker, armed with his portable set and microphone in hand, at work in the depot.

The Traffic Office is in a building some dozen metres away from the western end of the group of sheds.

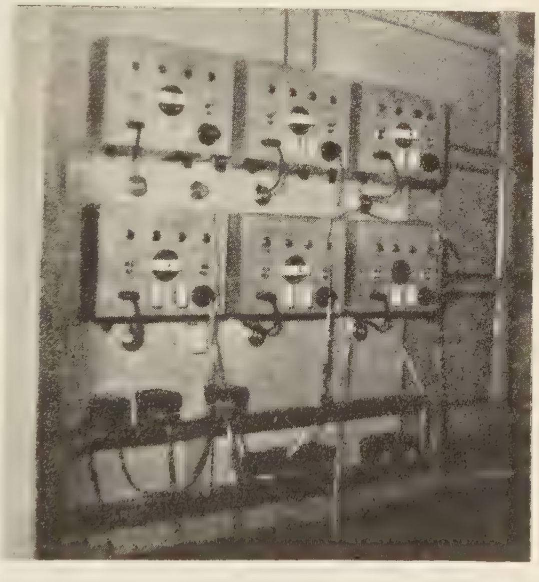
Radio-electric links.

Telecontrolled from the Traffic Office, there are 4 fixed transceiver posts, making use of modulation of frequency, installed in the depot. Each post is tuned in to its own frequency. There is a mobile post for each fixed post with the same frequency as the latter. The establishment has four frequencies allotted to it, between 160 and 161 megacycles. There is a fixed post and a mobile post for each of these frequencies.

The mobile posts weight 1.900 kg (4.18 lbs.) in working order. They take up very little space and are carried in a leather case, which the operator fastens on his back at belt level by means of straps.

Each portable post is worked by a set of removable accumulators fitted in it which last for approximately 4 h. The sets of accumulators are easily and quickly changed, so that this is no drawback to their use. Twelve sets of accumulators enable 3 portable sets to work for a 24 h period, with one portable set in reserve.

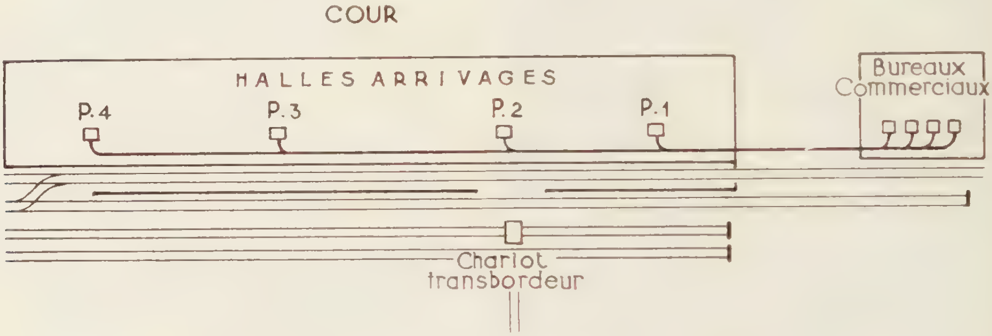
The accumulators are recharged by automatic charging equipment which does not require any supervision.



The automatic accumulator charging equipment.

The fixed posts are operated from the Traffic Office by 4 telecontrol boxes. Each box can control through a 4-position switch anyone of the 4 fixed posts. The boxes are fitted with a call indicator corresponding to each portable set, which facilitates getting in touch with it during the work without looking for the transmitting post.

Each portable set is equipped with a micro loud speaker which the operator holds in his hand. Headphones are used in the fixed posts.



Diagrammatic arrangement of the installations P 1, P 2, P 3, P 4; control boxes for the fixed posts.

N. B. — Cour = yard. — Halles arrivages = arrival depot. — Bureaux commerciaux = traffic office. — Chariot transbordeur = transhipment trucks.

ORGANISATION OF THE CHECKING.

Volume of traffic.

There is on the average 175 t of parcels traffic daily into Saint-Sauveur station, representing 450 consignments.

At peak periods (which occur during the spring at the time of Lille Trade Fair and during the last three months of the year), the establishment has to deal with more than 250 t of incoming traffic daily, which represents between 700 and 800 consignments.

Unloading starts at 11 p.m. The last consignments are in position at 8 a.m. The peak hour is about 4 a.m.

At 6.30 a.m., about 85 % of the parcels are in place in the bays, ready to be checked.

Preliminary operations before checking.

In order to get the maximum output from the installations, the bills must be at the Traffic Office in good time and available to the radio-operator at the fixed post linked up with the portable set operator in the depot with the parcels.

The parcels in the depot and the documents in the office must be classified in an identical way and the operations required to find them must take very little time if any.

The parcels, sorted as they are unloaded from the wagons, are put in the bays after being unloaded. The large consignments are put directly into the bays, the smaller behind the bays whilst awaiting the arrival of the checker. The parcels are arranged according to the consignment, with their marks and labels clearly visible. This work is done by the handling contractor. Each document as soon as it arrives in the Traffic Office is zoned by a special employee, which means that according to the address of the consignee it is marked with the number of the appropriate bay followed by a letter A, B or C if necessary (these letters specifying definite lots in each bay in order to facilitate making up the loads for the haulier). This number, followed by its lot indication, is that of the bay in which are the parcel or parcels for which the document in question forms the transport contract.

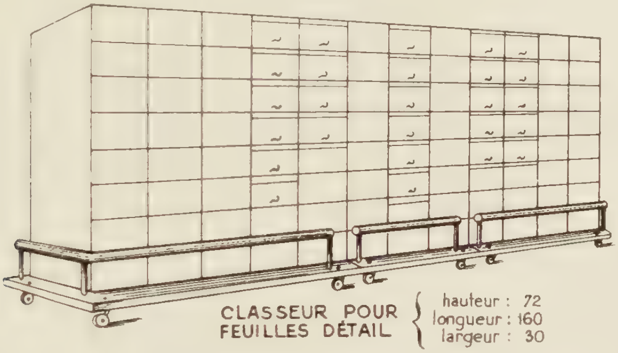
After checking the charge made, the document is placed in a special double entry case. Red cases take the sheets to be checked, which are put in place by the zoner. Yellow cases take the sheets that have been checked. There are a few blue cases for sheets that follow a special circuit.

The whole of the file is divided up into three movable parts, which can be arranged in line or in a horseshoe so that one or several operators can work simultaneously according to need.

Checking.

This operation consists in comparing the document forming the transport contract with the parcel or parcels which are being transported.

Over the radio link with the Traffic Office where a clerk has spread out in front of him the sheets from the red case corresponding to the bay where the checker is working, the latter reads out the address of the consignee of a parcel. If he has the sheet, the Office clerk reads out the address of the consignor, the consigning station, the date of consignment, the nature of the parcel or parcels and their marks. The man in the depot checks the information received from his colleague in the Office. All he then has to do is to mark the parcel with the conventional sign showing that it has been checked, when it can be put in its final position awaiting removal by the haulier. The Office clerk then places the sheet that has been checked in the corresponding yellow case for the



Files for the parcels documents:
height: 72; length: 160; width: 50.

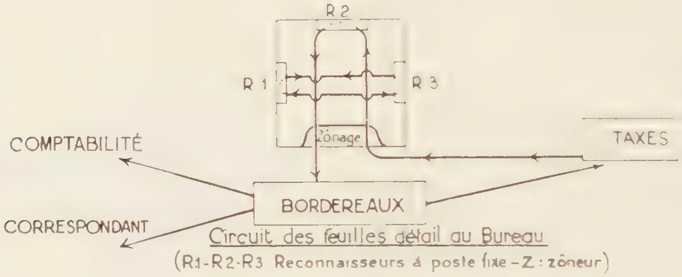
There is a series of cases for each bay: one red for the sheets to be checked, one or more yellow cases for the sheets that have been checked, each of these latter being allocated to the different lots which may be in the bay.

Each case is closed by a plexiglass shutter on the side from which the sheets are taken out. This shutter prevents the sheets to be checked from getting mixed up with those that have been checked. As they are transparent, these shutters make it possible to see how many sheets there are to check or that have been checked. This enables the office to direct the checker in the depot to the bays where there are the most sheets to be checked.

zoning index to which it has been allocated by the zoner.

At the end of each working session, a provisional delivery sheet is got out for the parcels without documents, and a part delivery sheet for incomplete consignments.

This method of working avoids long conversations and allow of very rapid checking. In practice, one checking group (one fixed post operator and one portable set operator) begins working between 1 and 2 a.m. Between 5 and 7 a.m. three groups are working together. After 7 a.m. until 1 p.m. only two groups are working, the actual work of checking being completed between 11 and 12 a.m.


R 2
R 1
R 3
Zonage
COMPTABILITÉ
TAXES
BORDEREAUX
CORRESPONDANT
Circuit des feuilles détail au Bureau
(R1-R2-R3 Reconnaisseurs à poste fixe – Z : zôneur)

Circuit taken by the documents at the Office
(R 1-R 2-R 3 fixed post checker. — Z : zoner).

N. B. — Comptabilité = accounts. — Bordereaux = lists. — Correspondant = haulier.

The handling over of the arrivals to the haulier is done by means of lists which are completed as checking takes place from 5 a.m. onwards, being completed by 7.30 a.m. for the morning delivery, and towards 11 a.m. for the afternoon delivery.

Advantages of the system.

This method of checking has definite advantages. First of all, the documents are much safer as they no longer have to be sent from the Traffic Office to the depot and from the depot back to the Office after checking has taken place. The difficult job of allocating the right documents to the different bays before and after checking has been done away with. Moreover, it is easy to control and supervise the checking, as an official from the office can listen in at any time from the Office and follow the operations.

The work of checking is simplified. The office clerk with the documents is working under excellent conditions. He can spread the documents out on his table, whereas with the classic system, the checker has to move about among the parcels with the documents in his hand, and most part of the year he has to work in a draught which does not make his work any easier.

The high efficiency of this organisation has made it possible to reduce the number of men working in the depot by 40 %, whilst improving the working conditions and turnover.

Finally, with the classic system, 60 % of the arrivals were ready for delivery by 7.30 a.m. Checking by radio makes it possible to have more than 80 % ready by the same time.

The experiment has therefore been conclusive and owing to its possibilities, the radio link opens up many new possibilities of use likely to improve very appreciably working conditions whilst at the same time proving a very profitable factor.

[625. 13 (42)]

London Transport's experimental tube tunnels.

Speed and economy of new methods of tunnel construction.

The experimental tunnels now being built by London Transport in the Finsbury Park area have shown that tube tunnels can now be built in good London clay at about twice the speed and more economically than with earlier methods.

The object of the work is to give full-scale experience of new methods of tunnel construction in readiness for the Victoria Line and other future tube lines. The experimental length is on the alignment of the Victoria Line and will be incorporated into it when authority to build the line is given. The new methods would save some millions of pounds on the cost of the 11 1/2-mile line.

It is 21 years since a new section of tube railway was built by London Transport and 54 years since the last tube railway across central London was built. In the interim period new knowledge of the stresses and strains in tube tunnels has been obtained by special tests including the removal of original tube linings, and as a result new designs of linings have been evolved entailing new methods of tunnelling. London Transport considered it essential that it should test these new methods so that the quickest and most economical form of tube tunnelling available could be used where appropriate for the Victoria Line. Contracts were therefore placed early last year for the construction of two experimenital lengths of twin tunnel, one running from Finsbury Park to Manor House and the other from Netherton Road (Tottenham) to Manor House, where the two lengths of tunnel meet. The total length of twin tunnel involved is about one mile, and the cost will be about £ 1 million.

The Finsbury Park-Manor House section is being lined with concrete block segments of a new pattern and the Netherton Road-Manor House section uses a new type of flexible jointed cast iron lining without bolts and with much shallower flanges than those of conventional linings. Previously, tube tunnels have been lined with bolted cast iron segments built inside a shield and with cement grout forced into the space left as the shield moves on between the outside of the segments and the surrounding ground. Although reliable, this method is slow and more expensive.

The tunnels are being bored by a rotary type of shield called a « drum digger » which can work much faster than any previous type of shield used for tube railway construction in London and which provides for conveyors to remove the spoil.

Using the cast-iron lining method, the contractors for the eastern half of the tunnel have just completed the driving of a 934-ft. length of tube tunnel, including the excavation and lining, in two weeks. This, representing a speed of 3 1/2 ft. of new tunnel built per working hour, is believed to be a world record for driving and lining a tunnel of this size through clay soil. It is about double the speed which would be considered good going with previous techniques.

One drive of each type of tunnel has now reached Manor House, where a cross passage has been built connecting the two. This also enables the engineers to close their survey traverse at tunnel level and thus obtain very accurate junctions between the second and first drives. Work is now complete on the second drive from the Netherton Road end, and the drum digger has started on the second drive from the Finsbury Park site.

When the tunnels eventually become part of the Victoria Line, the cross passage at

Manor House will be extended to give access to an electrical sub-station serving the new line.

DETAILS OF CONSTRUCTION.

Access shafts.

There are working sites and shafts at the corner of Netherton Road and Seven Sisters Road (Tottenham), and in Finsbury Park itself, near the Eastern Region main line from Kings Cross to the North.

The Netherton Road shaft, 25 ft. in diameter, is 60 ft. deep. This shaft will be a permanent part of the Victoria line and will be used for ventilation and emergency stairs. From its foot an access tunnel runs a short distance to the line of the running tunnels, where chambers large enough to permit the assembly of the « drum digger » rotary shields have been excavated by pneumatic spades and lined with bolted cast iron segments. At this site, excavated spoil is brought to the surface by a crane which lifts the 1 1/4 cu. yd. skips off the 2 ft. gauge bogies which have brought the spoil, in trains hauled by battery locomotives, along the completed section of the tunnels. The skips are loaded by conveyor from the rotary cutters at the face and are emptied on to the ground, the spoil being loaded into lorries by a 1 cu. yd. mobile shovel. A small electrically-operated traverser is used to manoeuvre the skips at the bottom of the shaft.

At the Finsbury Park working site the shaft is 15 ft. in diameter and 60 ft. deep. As at the other site, an access tunnel leads from its foot to the line of the running tunnels and there are two shield assembly chambers. The running tunnels are on a gradient of 1 in 47 down and the loaded 2/3 cu. yd. skips are hauled by an electric winch sited in the shield assembly chamber.

The skips tip the spoil on to a belt conveyor in the access tunnel and the conveyor delivers the spoil to the foot of the shaft where it is hoisted to the surface by a vertical bucket elevator. The buckets are warmed by hot air to prevent the clay from sticking to the metal. Originally, the clay was carried to an elevated hopper under which lorries could be loaded by gravity but is has now been found better to bring the spoil to ground level and use a 1 cu. yd. mobile shovel for loading.

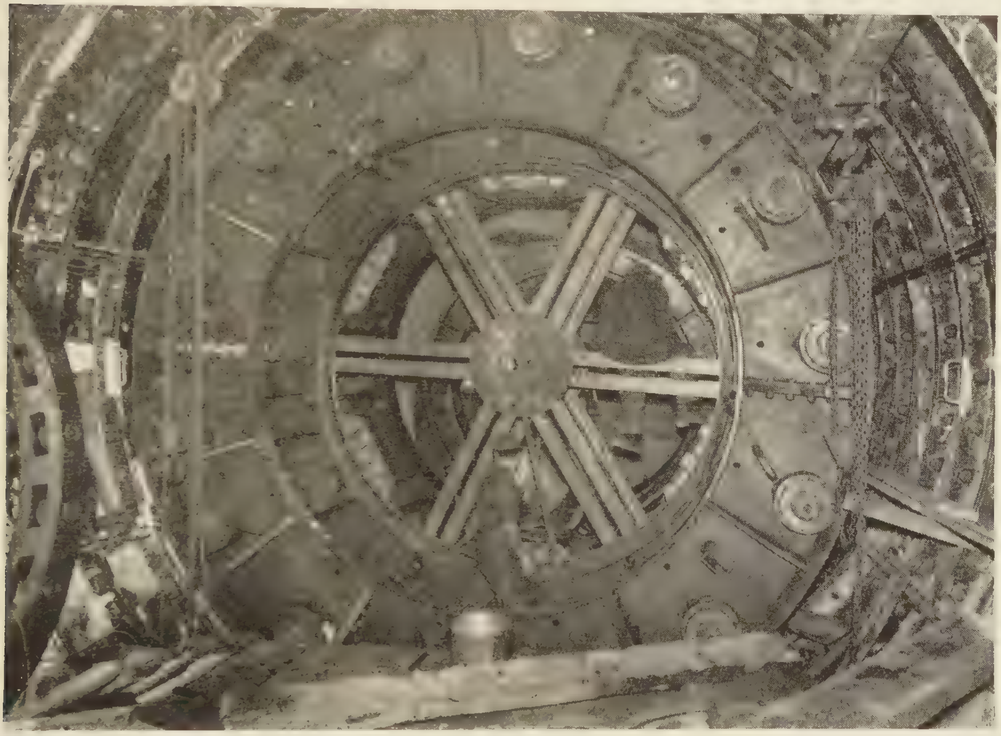
Tunnelling equipment.

The drum digger type of shield has been used previously on the tunnelling work for the Metropolitan Water Board's Thames to Lee Valley water tunnel. The experimental railway tunnels are of much greater size than the water tunnel, and the drum digger shields are therefore on a larger scale. The general design, however, remains unaltered.

The drum digger for the concrete-lined tunnels has an external diameter of 14 ft. and that for the cast iron-lined tunnels 13 ft. 1 in.

The drum digger consists essentially of two drums. That for the 14 ft. diameter tunnels has an outer drum of 14 ft. external diameter and 9 ft. in length and the leading end is bevelled to form a cutting edge. Within the main drum is a 7 ft. 6 in. diameter rotating drum 5 ft. 6 in. in length carried on two roller races and provided with a thrust ring to take the axial load from the rotating cutters. The cutting teeth themselves are mounted on six arms at the front of the shield, each carrying eight removable teeth. They are mounted at the outer edge of the inner, rotating drum, so that they cut the area in front of the space between inner and outer drums. The area in front of the inner drum is cut by teeth mounted on a removable arm across the diameter of the inner drum. The teeth may be replaced after hand mining a small cavity in front of the arms. The inner drum, and the cutting teeth with it, can be turned at speeds of up to 4 r.p.m. by six hydraulic motors driving through gear boxes. Pinions at the driving ends of the gear boxes engage the teeth of a large gear ring bolted to the rotating section of the drum digger. The hydraulic motors are controlled by a valve within the shield.

The forward movement of the shield is given by 14 hydraulic rams arranged at equal spacing round the periphery of the shield and pushing against the last completed tunnel ring. These rams, which have a stroke of 2 ft. 8 in. and operate at a working pressure of about 2 000 lb. per sq. in., are individually controlled by an operator standing within the shield casing but behind the rotating inner drum.



Drum digger shield for north drive of southbound tunnel, showing gear boxes installed. The temporary spider and trammel used during erection can also be seen.

The ram operator is provided with sighting guides which show him whether the shield is on the correct line and level and he can apply or reduce pressure to any of the ramps to correct any tendency to deviate to the right or left or up or down. The sighting devices used on the two shields employed in the experimental tunnel are different, the more elaborate being arranged so that the ram operator can sight the image of a cross of light on a graduated mirror and obtain a direct indication of any deviation from true line or level. The source of light is a lamp placed further back along the tunnel from which a beam passes through two cruciform slits in markers fixed to the roof of the tunnel and placed precisely in the correct position by the use of surveying instruments. When driving a curved length of tunnel, the mirror sighting device is adjusted against a scale after each ring of lining is erected to keep the shield on the proper alignment.

The clay is cut by the rotating teeth and guided by scoops and paddles into a hopper within the shield where it drops on to the end of an inclined electrically-driven belt conveyor. This discharges on to the main horizontal belt conveyor which carries the excavated clay back along a staging, from which it is discharged into the skips on 2 ft. gauge track on each side of the horizontal conveyor.

Under the conveyor staging is a 200 HP electric motor driving pumps to provide hydraulic power for the shield motors. A separate 12 1/2 HP electric motor supplies hydraulic power for the rams. At the sides of the conveyor belt, at the shield end, are electric hoists for handling the tunnel lining segments.

To the rear of the conveyor and the hydraulic power unit the tracks on each side of the conveyor converge into one and pass down a short ramp to join the main tunnel track.

The whole of this apparatus from immediately behind the shield to the rail ramp at the rear is mounted on an articulated trailing platform, attached to the rear of the shield and drawn forward as the shield advances. When the rams have pushed the shield forward the width of a ring of tunnel lining, i.e. 2 ft., they are retracted. A ring is then built in the space between the last completed ring and the rear of the shield. When this has been completed the whole cycle recommences, the rams pushing against the newly-installed ring.

Considerable heat is generated at the working face and the oil in the hydraulic system is cooled by a heat exchanger. The cooling water is fed to the exchanger by piping from the shaft and on the return circuit is taken to the head of the shaft and passed through a cooler before being returned to the tunnel. The pipes of the cooling water circuit, like the power leads to the working face, have to be extended from time to time as work progresses.

The drum digger is capable, in good conditions, of advancing more than 60 ft. a day, working three 8 h shifts, over long periods — a much higher speed than has ever been maintained before in building a tube railway tunnel. The maximum length driven to date in one 24 h period is 88 ft.

Apart from the smaller external diameter of 13 ft. 1 in., the drum digger used for the cast iron lined tunnels is similar in construction and operation.

Tunnel linings.

The lining of the tunnels built from the Netherton Road site is of unbolted flexible jointed cast iron segments. There are six segments, each 1 in. in thickness, to every 2 ft. tunnel ring. One end of each segment is concave and the other convex, so that the ends of the segments form knuckle joints, each fitting into another.

The segments are put into place in the space left behind the shield when the rams are withdrawn, the two forming the invert (bottom) being laid first, then the side segments. Finally, the segments forming the roof are manhandled into place and held by « needles » mounted at the rear of the shield. The two segments forming the floor of the tunnel are cast with small recesses at their upper ends and when the segments have all been erected, hydraulic jacks are fitted into these recesses and a force of 15 tons per jack is applied to the ring segments, expanding them against the clay outside. This expansion creates a small gap between the segments forming the sides and those forming the floor or invert of the tunnel. Into each of these gaps are placed first two cast-iron knuckle-pieces shaped to conform to the contour of the segments below and then two pairs of cast-iron taper packings which hold the whole ring firmly in place when the pressure of the jacks is released.

The segments have shallow interior ribs which are enlarged to form perforated lugs at regular spacing round the periphery of the ring for handling purposes and to provide for the fixing of the railway equipment in due course e.g. signal equipment and cable brackets, noise reduction screens, and tunnel lighting. The internal diameter of this type of lining, from rib surface to rib surface, is 12 ft. 8 in. This is somewhat more than is absolutely necessary but the external diameter is the same as that required for the conventional cast-iron lining which may have to be used on certain lengths where there are junctions, cross-passages, or other special features.

The conventional lining, of 12 ft. internal diameter, has deep recesses which can be used to accommodate comparatively bulky signal equipment and other apparatus. The recesses in the flexible jointed cast-iron lining are shallow, so that all equipment necessarily stands out from the inner surface of the tunnel lining.

The pre-cast concrete lining of the other half of the tunnels is also of a new type. The tunnel itself is driven by the larger of the two drum diggers, to give space for a tube of 12 ft. 6 in. internal diameter with a lining of pre-cast concrete segments, of which various thicknesses — from 4 1/2 in. to 9 in. — have been tested. The final thickness to be used for the Victoria Line may be 6 in.

Each tunnel ring is made up of 14 identical segments having one cross joint face convex and the other concave, so that they fit together with knuckle joints similar to those used for the iron segments. When the 14 segments are assembled a gap of about 7 in. remains at the top. This gap is filled by a pair of reinforced concrete folding wedges having plane contact faces and concave and convex faces respectively in contact with the segments on each side. The wedge with the wide end nearer to the shield is driven home by a pair of small hydraulic rams while the other wedge is held in position. These two wedges hold the whole ring firmly in place. The concrete segments are cast with four holes equally spaced round the interior circumference. These are used for handling in the tunnel and will also be used, with expanding bolts, for fixing tunnel equipment, serving the same purpose as the ribs of the cast-iron segments. The concrete segments are handled by hoists at the working face, an expanding bolt placed in one of the holes being used to lift them. They are lifted into their correct positions by a manipulator arm mounted at the rear of the shield and held in place by pull-out « needles » until the wedges are driven into position.

No grouting is used with either of the tunnel linings and there is nothing between the rings, except that wood packing pieces are inserted between the cast-iron segments to distribute the thrust of the shield rams.

[625 .172]

New methods in chemical weedkilling for railway lines,

by Dipl.-Eng. Löflund.

(*Die Bundesbahn*, No. 17, September, 1960.)

Water and weeds are the greatest enemies of the permanent way. It is very important to banish them both from railway lines. Chemical weedkilling is therefore of double interest : on the one hand to eliminate the destructive action of the root systems of weeds, and on the other to assure the proper draining conditions for the bed. If vegetable matter and humus is prevented from accumulating in the interstices in the ballast, water can be expected to drain away satisfactorily for a long period. In this sense, it might be said that the ideal weedkilling conditions would be those which made it possible to destroy all seeds blown on to the track by the wind, the germinated weeds and the growth of the roots from the very start. This result is very difficult to obtain in practice because the seeds and the root systems are very resistant. In addition, they appear throughout the warm season, so that any steps taken to kill them must retain their effectiveness from the beginning of spring until the end of the autumn.

Obviously weedkilling measures of this kind would be far too costly. In fact, a weedkilling spray looses its effectiveness in general after a few weeks or months. The steps taken must therefore be equally effective (radical) against all stages of growth of many different types of weeds — from the seed to the growing plant.

Are chemical methods the most suitable method of destroying vegetation to the desired extent ? Since 1925 until just after the Second World War, sodium chlorate ($NaClO_3$) was the only product used for weedkilling. This has a caustic effect on the stems and leaves, so that the plant dies after two or three weeks. Sometimes, the surface roots are also affected. In the case of resistant plants, especially those which reproduce themselves by means of runners or underground roots, the roots are generally unaffected. The plant therefore forms new growth after a short time. Sodium chlorate is therefore only completely successful when it is possible to apply it at least twice a year, as was done up to the last war.

When in 1948, the D.B. recommenced its systematic fight against weeds, sodium chlorate was again used to begin with. But this method could not be retained as :

1) the necessary quantities of sodium chlorate are only manufactured in Central Germany or abroad, and difficulty was experienced in obtaining supplies;

2) its long term drawbacks were becomming more and more obvious : caustic action on clothing and footwear, risk of vegetation sprayed with it catching fire in hot weather, and reduced insulation of the tracks;

3) before weedkilling could be recommenced after the war such a varied and strong vegetation had grown up that sodium chlorate was powerless to deal with it.

Since 1953, steps have been taken to try and improve the effectiveness of sodium chlorate and eliminate its drawbacks. Various products have been added to the solution for this purpose. For example, grasses were particularly affected by an addition of sodium trichloracetate ($Cl_3C\text{-}COONa$) and sodium carbonate (Na_2CO_3). To kill dicotyledonous plants 2.4 dichlorphenoxyacetic acid was added to the sodium salts ($C_6\,H_3\,Cl_2O\,CH_2\,COOH$). To reduce the risk of fire, magnesium chloride ($Mg\,Cl_2$) was also added, which is also known as « special Z salt » and is very hygroscopic. These additions, with others, were tried in different doses over several years. The proportion of sodium chlorate was reduced in this way by about 1/4 to 1/3, but the results obtained never fully came up to expectations.

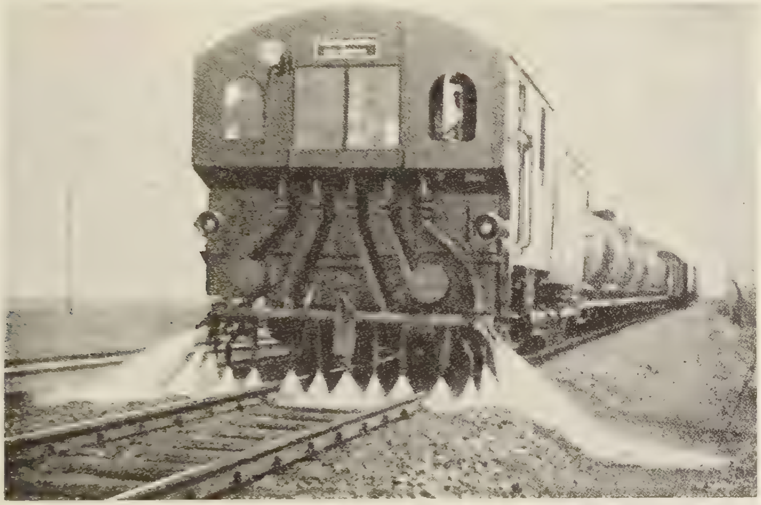


Fig. 1. — Track spraying train; in the foreground, spray tank; behind, tank wagons for supply of spray wash.

In addition to the sodium chlorate solution, for some 30 years a solution of calcium chlorate had also been used in the form of pulp. In 1957, chlorate of calcium ($Ca[CL\,O_3]_2$) made its commercial appearance under a special trade name with new additions of active ingredients. Its weed-killing properties are most satisfactory, so that that this product is still used at the present time in some regions. Unfortunately, it has certain drawbacks for railway operating. For example, it has a tendency to make the rails slippery. This can be overcome, however, by fitting protective covers on the spraying wagon above the rails. If various unfavourable circumstances are all present, the product can also have a bad effect on the electrical conductivity of insulated sections of track. It is not yet possible to say whether it will continue to give satisfaction.

In 1957, when new chemical products for weedkilling were put on the market, the D.B. gave up using sodium chlorate. The new products are known under the designations « 370 » and « 371 ». They are manufactured in Germany under a Swiss patent. These products which are extremely toxic to all vegetation are very concentrated and have an atrazine base and they have no harmful effects upon men or animals. They penetrate into the nutritional cycle of the plant and destroy the vital function of the cells. After 4 to 5 weeks, the plant dies. Through the flow of the sap, these poisons also work internally on the roots, so that the plant is unable to make any new growth.

Each product is made up of a large number of ingredients which assure a wide field of effectiveness. Products 370 and 371 are made up especially for the flora met with on the permanent way and contain products which act above all on gramineous plants and dicotyledons. The precision with which these new chemical products can be regulated to destroy a given plant can be seen from the fact that there is a special one for vines. Product « 371 W » contains all the active elements with the exception of that for vines. The D.B. uses this product on lines running through the vineyards so as not to risk any damage to the vines.

The advantages of these new chemical products are so great that the D.B. is using them almost exclusively for its weedkilling programme. These advantages are essentially :

1) low consumption of chemical products (1 g/m² compared with 24 g/m² previously);

2) reduced consumption of water (0.2 l/m² compared with 0.8 l/m² previously) so that one load sprays a greater distance;

3) unaffected by heat or rain, effective up to 6 months;

4) no reduction in the insulation value of the track;

5) no risk of fire;

6) no danger for humans or animals, so that no strict precautions have to be taken to safeguard the staff.

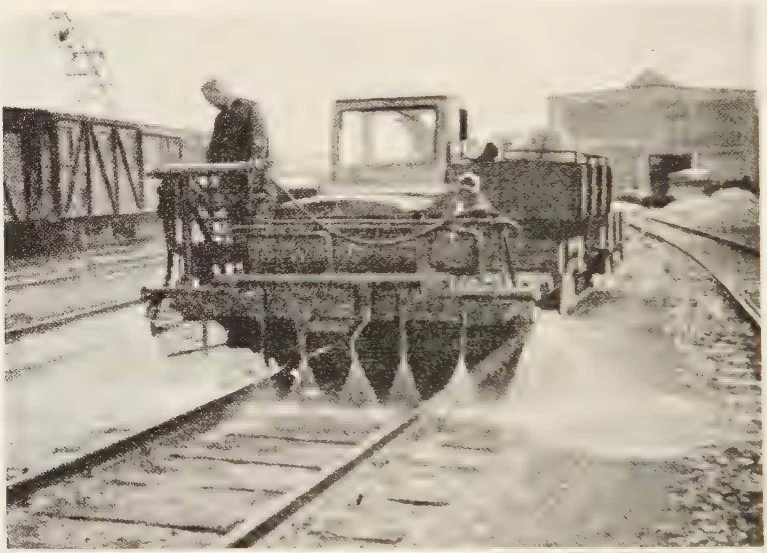


Fig. 2. — Spraying machine for stations, mounted on a heavy motor truck. In the centre of the set of nozzles, hollow cone equipment; on the outside, solid cone equipment.

During trials, which lasted two years, it was apparent that the effectiveness of these products could be still further increased to a great extent by making use of the alternate spraying method. This consists of using the first year, between the end of summer and the autumn, a pulverised form of product 371 to kill all the gramineous and dicotyledonous plants which are difficult to destroy. During the spring of the second year, at the beginning of the period of growth, a second treatment is given using product 370 which is intended to destroy seed bearing plants. The action of these products is so lasting that no further treatment is necessary in a good year, until the autumn of the third year, when the cycle is started once again. It was found that very little vegetation grew in the interval, particularly because the wash applied remains effective for about 6 months. This is approaching the ideal solution in which, as we said at the beginning, all the seeds and seedlings come into contact with the weedkilling product as soon as they appear and are immediately destroyed.

Another advantage of alternate spraying lies in the 15 month gap after the spring treatment. If the region to be sprayed is divided into two sections, to begin with the first section is sprayed during the first autumn. During the second autumn, the second section is sprayed, and nothing has to be done in the first section. Each spraying only has to cover half the region concerned. The work of the spraying wagons is therefore reduced and they need not work to such a close timetable. This enables the work to be more carefully planned according to the season and the particularities of the vegetation.

The change in weedkilling practice also meant adapting the weedkilling trains, of which the German Federal Railways have several. These consist of a spraying wagon and four to six tank wagons each holding on the average 30 m³. There is also a covered wagon to carry the tools and spare chemical products as well as a wagon to accommodate the staff. The spraying wagon has a set of pipes, motor pump set and pressure regulating valve. As the output with the new products is less than a quarter of that formerly needed, the equipment had to be adjusted. The D.B. made these adjustments with the greatest care. By this means, they not only arrived at the correct output of spray, but also a better distribution of the spray over the whole width of the track which is 5 m on the average. The new nozzles with solid cones (unlike the old nozzles with hollow cones) have given good results. The outside nozzle has been given a particularly wide spraying angle so as to cover not only the bed of ballast but also the side track. So that this latter can be sprayed properly, even when its width varies, the pivoting device of the old installation has been retained. In fact, at the present time, particular importance is attached to spraying the side tracks as this is the point from which the weeds spread onto the track.

As the spray is harmless, there is no need to keep a close watch on the track. As a result, it is no longer necessary to push the rake. If a level crossing should get sprayed, no harm can be caused to the road traffic. Consequently as laid down, if the speed of the spraying train is increased from 35 to 60 km (21 to 37 miles)/h, great care must be paid to adjoining cultivated fields, because the spray will travel further with the increased wind due to the faster running.

At the same time, there has been a new evolution in connection with weedkilling in the stations. A spraying unit has been designed consisting of a tank, a motorpump and set of nozzles which can be mounted on a heavy motor truck with the minimum of operations. The motor truck is much more mobile in the stations than the old spraying trains. The unit is stored in the equipment shed of the line in question and can be asked for when required. A sufficient number have been purchased for each Management to have four; it is hoped to have two for every operating section.

The arrangement of the nozzles on the spraying machine for stations is more or less the same as on the spraying wagons. A pipe makes it possible to spray even areas that are some way off. Using the new chemical products, the 6 m³ of liquid carried is sufficient for about 6 km of station sidings.

The Deutsche Bundesbahn spend some 6 to 8 million DM each year on chemical products for weedkilling, without mentioning the cost of maintaining the weedkilling machines and trains and the carrying out of the spraying. The improvements already made allow it to be hoped that these sums are spent in the best possible way. The carrying out of the rational method of alternate spraying should result in a few years in a railway system without any obnoxious weeds. It is expected that it will then be possible to reduce the concentration of the chemical products. The amount spent on them will then also be reduced. Nonetheless, work is still being done on improving the new products as well as extending their sphere of action, so as to make it possible to destroy even those plants which so far have proved resistant to treatment. Likewise their action should also be extended to cover plants which are only found in certain regions (in the Alps for example). Finally the D.B. is following very closely the new products of the chemical industry in order to apply them to weedkilling on the railway.

[656 .254]

Automatic operational testing of track-diagram push-button type signalling equipment,

by Willi GEBER.

(*Signal und Draht*, No. 6, June 1960.)

1. General.

The original task of railway signalling is to ensure the safety of railway operation. Safety can be endangered by a variety of causes; there may be a failure of the human element, or of the technical installations. Even with the very first signalling devices, the attempt was made to eliminate the possibility of human errors as far as possible; hence the mechanical interlocking between the mechanical signal levers and signal blocking devices of the section block system. As the complexity of operation increased, the possibilities of erroneous actions on the part of the operators also became more and more numerous. Even conventional railway signalling technique is based on an extensive safety system which can hardly be improved upon. In earlier times, improvements in signalling installations were mostly initiated as a result of accidents. At that time, preference was given to mechanical interlocking, not because the potentialities of electric circuiting were unknown, but because the mechanical interlockings were regarded as safer. Even to-day, this opinion is still frequently voiced. But, owing to failures caused by wear, by excessive strain on the material leading to fracture, by corrosion, etc., a gradual change of opinion is taking place. In modern signalling technique, mechanical interlockings are as far as possible avoided, so as to obviate the need for applying mechanical forces, and to eliminate wear. True, there had been attempts to guard against such mechanical failures by means of exactly defined tests for which special devices were created. It was, for instance, proposed that the degree of wear should be detected before it could become dangerous. But such tests can only be carried out at certain intervals, without the guarantee that, perhaps owing to changes in circumstances, a dangerous condition might not, after all, arise during the interval.

It seemed preferable to design the signalling installations in such a way that any faulty condition must automatically become apparent because the fault will impede operation, and must thus, of necessity, be attended to. This will, of course, only be possible as long as each individual operation is tested for correct effect before the next step can be taken. It is hardly possible, however, for such a procedure to be based on mechanical means. With electrical interdependencies, on the other hand, this objective has already been largely attained. According to the « General Directives concerning Signalling Circuits », the trouble must become apparent at once, or on the occasion of the next move. A drawback of this solution lies in the fact that any fault will only be detected in the course of operation so that nearly every fault will impede normal operation.

In order to clear such trouble immediately, it is, with major installations, often necessary to keep a maintenance man on duty continuously so that he can attend to a fault at once. In this way, it is possible to keep the incidence of operating breakdowns within tolerable limits. To circumvent these difficulties, it seems logical to carry out an operational test in off-peak periods, e.g. at night. By means of such a test, it is possible to detect a fault before it is able to impede operation. As it would not be economic to have these tests carried out by a special maintenance man, it would seem logical to arrange for this test to be carried out automatically, and to record the faults thus detected by means of an automatic printer. This would permit the detection of a fault before it can impede operation. At the same time, the maintenance man is able to ascertain from the recording the location and nature of the fault. This would enable the trouble clearance work to be carried out during off-peak periods of operation, and the continuous manning of the breakdown service could be reduced to a minimum. Moreover, if trouble clearance work is carried out during off-peak periods, the faults can be located and remedied more easily.

On the strength of these considerations, the Saarbrücken Region of the German Federal Railway have developed and installed a device which automatically tests the working of the signalling installation and records any faults thus detected in the form of a printed message (fig. 1).

In the present case, the testing apparatus was built into a Lorenz track-diagram push-button type signal control installation. But the apparatus can also be used in conjunction with any other, similar installation.

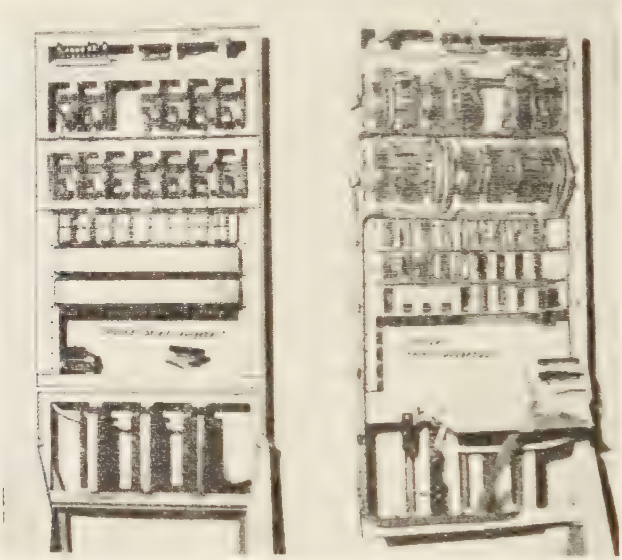


Fig. 1 — Operational testing apparatus.

a) Front. — *b*) Rear

N. B. — Drucker bereits ausgebaut — printer already removed

2. Description of the apparatus.

In designing the apparatus, it was regarded as essential that the testing equipment should be arranged in parallel to the existing installation, without interfering with the latter. It appeared desirable to provide the apparatus with a plug board and the existing installation with plug sockets, so that it is possible to mount the testing equipment in any signalling installation of this type, depending on local requirements.

2.1. *Setting up a route.*

Figures 2 *a* and 2 *b* illustrate the connection scheme required for a train arrival. As the diagram shows, the testing apparatus can be actuated by connecting a 60 V D.C. supply to terminal 5 b 4 in the entrance group (home signal) and to terminal 1 a 2 in the exit and runaway section group. The necessary connections at the intermediate distributor frame are shown in broken lines. As is well known, the operation of the push buttons is followed by the route selection, and this process must therefore also take place in the case of a simulated connection through a rotary switch. The further progress of the switching operations depends on the release of the push buttons. To simulate this action, a relay has been connected in parallel to the pilot lights indicating the position of the push buttons on the operating desk (fig. 3). By means of contact (1) in figures 2 *a* and 2 *b*, this relay causes the normal sequence to be cut out. All further operations, up to the change of the signal indication, now follow automatically as with normal operation. The route for a departure movement is set up, and the signal changed, in a similar way, except that this time the push button relays corresponding to the departure movement are energized. The selec-

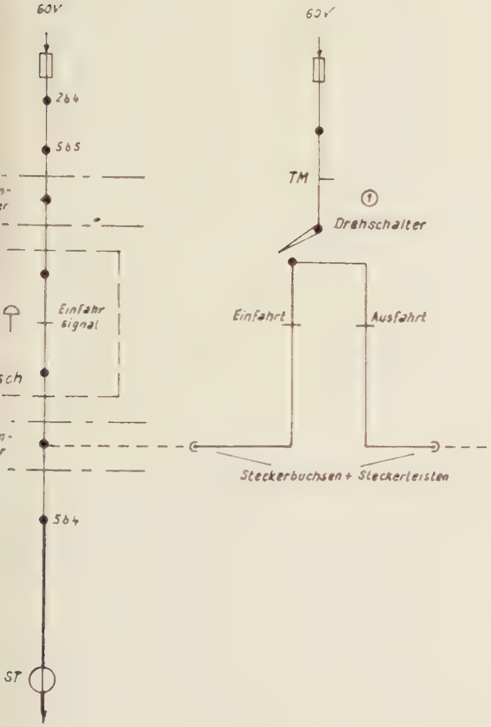


Fig. 2 *a*. — Home signal.

N. B. — Einfahr signal = home signal. — Tisch = desk. — Zwischenverteiler = intermediate distributor. — Drehschalter = rotary switch. — Ausfahrt = departure. — Einfahrt = arrival. — Steckerbuchsen + Steckerleisten = plug sockets and plug boards.

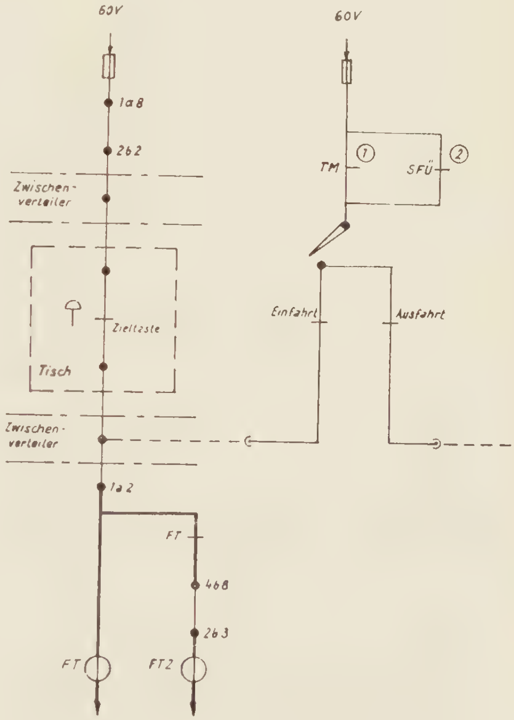


Fig. 2 *b*. — Exit group and runaway section.

N. B. — Zieltaste = exit push-button. — Tisch = desk. — Zwischenverteiler = intermediate distributor. — Einfahrt = arrival. — Ausfahrt = departure.

tion is carried out by means of a manual operation of the arrival or departure switches.

2.2. *Route cancellation.*

2.21. *Arrivals.*

When the signal indication has changed, the route cancellation (auxiliary cancellation) can be initiated.

connections are shown as broken lines. The cancellation must not take place before the home signal has shown a « clear » indication. FT 2 is therefore connected by means of a contact of the « signal clear » indicator SFÜ shown in figure 5 which is likewise connected in parallel to the desk pilot light. To ensure the completion of the route cancellation, relay SFÜ is fitted with a time lag device which enables the route to be completely released so that the push-button position repeater is in the normal position.

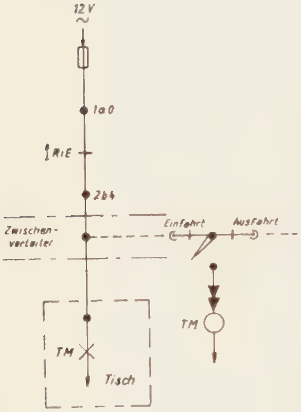


Fig. 3. — Push-button position indicator.

N. B. — Tisch = desk. — Zwischenverteiler = intermediate distributor. — Einfahrt = arrival. — Ausfahrt = departure.

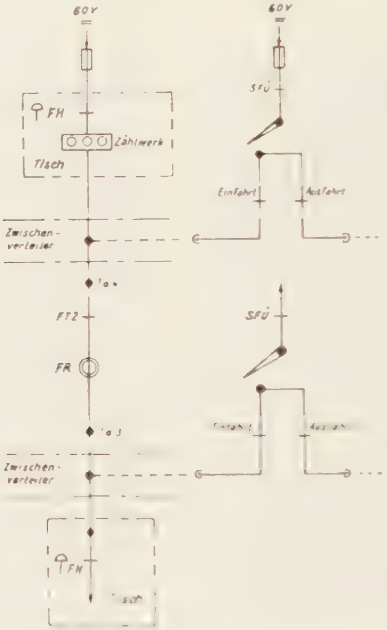


Fig. 4. — Route cancellation.

N. B. — Zählwerk = timing device. — Tisch = desk. — Zwischenverteiler = intermediate distributor. — Einfahrt = arrival. — Ausfhart = departure.

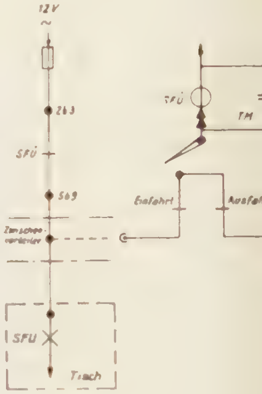


Fig. 5. — Signal clear indicator.

N. B. — Tisch = desk. — Zwischenverteiler = intermedia distributor. — Einfahrt = ar val. — Ausfahrt = departur

Figure 4 illustrates the cancellation of the route by means of exit push-button and auxiliary route key. With this operation, relay FT 2 in the exit group is energized, as shown in figure 2 *b*, by a contact of SFÜ (marked) (2). This cancellation can likewise take place in parallel to the operation of the push-button without actuating a timing device. The necessary

2.22. *Departures.*

With departure movements, the block relay set « outgoing » acts as exit group.

This relay group is therefore influenced, inter alia, by the route locking relay (F f), the « Route clear » indicator (FM), and the route control relay (FÜ). Also, in this group, the rotary switch is actuated. In order once to restore the normal position during the operational test, it is necessary either to block ahead by means of the block group push-button (BLGT) and the open-line push-button and to block back from the next station, or to return the rotary switch in the block relay set « outgoing » to the normal position by hand. Such interference should, however, be avoided if at all possible (*). Nor would such interference be possible, if all the relay groups are lead-sealed. As figure 6 shows, the connection scheme can also be arranged in such a way that the normal position of the rotary switch is automatically restored. As is apparent from the diagram, the block repeater relay (V b M) is energized when the rotary switch is in the zero position and the SFÜ relay is energized. The V b M relay now remains energized through self-excitation until the rotary switch has reached step 11. The impulses required for this operation are supplied by relay B 1.

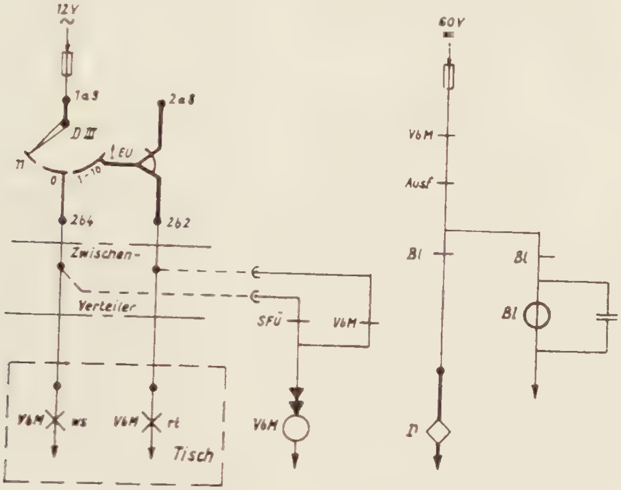


Fig. 6. — Rotary switch in the « outgoing » block relay set.

N. B. — Tisch = desk. — Zwischenverteiler = intermediate distributor.

2.3. *Design of the testing apparatus.*

With the entrance-exit signalling technique, all equally possible routes can also be set up and covered by signals, subject to limitations due to the positioning of the signals. It is therefore possible to set up, successively, all departure routes from tracks « 1 » to « *n* », or all arrival routes to tracks « 1 » to « *n* ». Each station track was therefore assigned to one step of a rotary switch, and each open-line track to one step of another rotary switch. If the first step of a rotary switch of a station track is connected, and if the rotary switch for the open-line tracks is set for a specific track, the corresponding step contacts will close, and the route will be

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(*) Cf. STEINFELD : « Prüfen von Spurplanstellwerken » (Testing of track-diagram push-button type signalling installations). « Signal und Draht », 1957, p. 133.

set up in the way described above. If all the relays belonging to the route are in the normal position, the rotary switch associated with the station tracks will switch over to the next station track (relay PÜ in fig. 7). This process is repeated until all the possible routes leading to the open-line track concerned have been set up and cancelled again. After this testing process, the apparatus is automatically restored to the normal position by means of appropriate auxiliary relays.

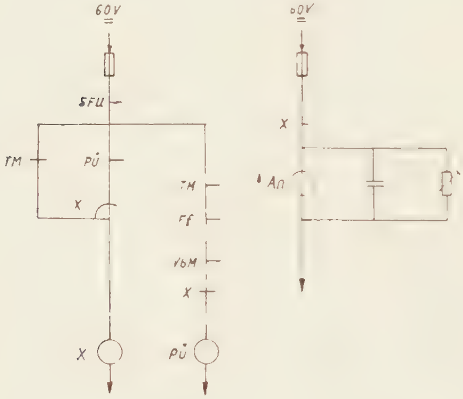

Fig. 7. — Actuation of rotary switch and trouble printer.

If, during the connection of a route, the « signal clear » proving relay SFÜ does not react, there is a fault in the installation. The fault is recorded by means of a type of printer known from telecommunication technique. The printer (« trouble printer ») is connected by means of relay An, as shown in figure 7. If relay *x* has been energized, by the setting up of the first route (relay TM), the voltage is disconnected by relay An; but, due to the parallel-connected capacitor, the relay has a time lag of 20 sec (the time lag can be adjusted as required). If relay *x* does not drop within 20 sec, relay An will drop, and will connect the trouble printer.

2.4. *Connection of the testing apparatus.*

The testing apparatus is switched in by the station inspector by means of the control panel, shown in figure 8. It is possible to switch in the apparatus in such a way that all the arrival and departure movements covered by the signalling installation are automatically tested one after the other. For operating reasons, however, this cannot be done at every station. The control panel is therefore so designed that the operational test can be carried out separately for each line. The station inspector will therefore press the « arrival » or « departure » button, respectively, and dial the number of the open-line track (as explained below). The apparatus is thereby switched in, and the automatic testing of the routes concerned is initiated.

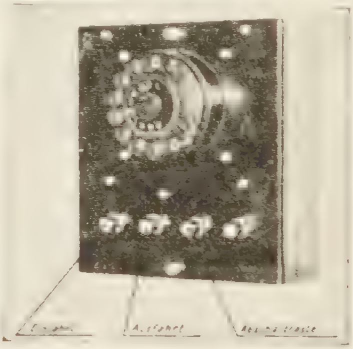

Fig. 8. — Control panel.

N. B. — Einfahrt = arrival. — Ausfahrt = departure. — Abschalttaste = cut-out push-button.

2.5. *Trouble printer.*

As already mentioned, the faults are recorded by means of a small automatic printer, of the type used in telecommunication technique for the automatic printing of telephone charges. This printing instrument is equipped with type wheels for the printing of :

a) the subscriber's code number (3 digits);

b) the charge (4 digits);

c) the clock time (3 digits).

For the purpose of fault recording, it is likewise necessary to print the clock time. These three digits were therefore left unaltered and are connected to a master clock in the normal way. The code numbers otherwise used for identifying the subscriber are used to denote the routes, which therefore had to be numbered. The first digit, from 1 to 0, denotes the open-line-tracks, so that these, too, had to be given consecutive numbers. Even numbers are assignated to arrival tracks, and odd numbers to departure tracks. In order to differentiate between arrivals and departures on single-track lines, such tracks are given two numbers, viz., an even number for arrivals, and an odd number for departures. The next two digits serve to denote the station tracks. Thus, a code « 2 11 » indicates an arrival from open-line track 2 to station track 11; code « 3 25 » denotes a departure from station track 25 to open-line track 3.

The four digits normally used for the printing of charges are used for recording the fault. As is already apparent from figures 2 to 6, any interference with the different groups was avoided, and the apparatus is merely connected to the intermediate distributor parallel to the operating desk. With this limitation, it is possible to simulate, and to record, the following operating contingencies of the routes which are also illuminated on the track diagram :

a) push-button position indicator TM (route selection completed);

b) route locking relay F f;

c) « signal clear » proving relay SFÜ;

d) for departure movements, the block repeater V b M.

By way of example, the table shows some recordings of an operational test, with explanations.

2.6. *Fault recording during operation.*

It is common knowledge that, when faults are investigated, the statements made by signal maintenance staff and operating staff, respectively, are sometimes in conflict with each other. It would therefore seem desirable to make an automatic distinction between operating errors and technical faults in the installation. For this purpose,

TABLE. — **Interpretation of printer recordings.**

Open-line track	Station track	TM	Ff	SFÜ	VbM	Time	Interpretation
2	01					4.15	At 4.15 a.m., arrival routes from open-line track 2 to station tracks 1 to 3 working correctly
2	02					4.15	
2	03					4.15	
2	04	0	1	1	0	4.16	At 4.16 a.m., no excitation obtained at route setting relay Ff for arrival from open-line track 2 to station track 4.
2	05	0	1	2	0	4.16	At 4.16 a.m., signal for arrival from open-line track 2 to station track 5 not cleared.
2	05	0	2	3	0	4.16	At 4.16 a.m., no excitation obtained at route setting relay Ff for arrival from open-line track 2 to station track 5.

it is not sufficient to record the operation of the auxiliary push-buttons, as has already been done with a number of installations, or to rely on the entries in part C of the trouble log book, as the auxiliary push-button can be operated at will. Their operation can therefore not be regarded as conclusive evidence of trouble. With the aid of the testing apparatus here described, it is also possible to record all the faults which have occurred in normal operation. When two co-acting push-buttons are operated, the route is connected (i.e. relay TM is energized). As already shown in figure 7, this will cause the relay *x* in the testing apparatus to be energized, and one contact of the latter will disconnect relay An. If this is not followed, within 20 sec (corresponding to the time lag imposed on relay An), by the connection of relay SFÜ (« signal clear » proving relay), the printer is switched in, and the recording is made in the same way as with the deliberate operational test.

3. Conclusions.

The descriptions and diagrams given above are merely schematic, and are only intended to explain the working of the testing apparatus; they are therefore not comprehensive. Reference has also been made to the method by which movements in both directions (arrival and departure) are tested. As the diagrams show, all the relays can be used for arrivals as well as departures. This arrangement was necessary in order to minimize the size of the installations. With the aid of this testing apparatus, a fault in a track-diagram push-button type signalling installation can be detected before it is able to impede operation. It is thus possible to reduce the incidence of breakdowns. It is common knowledge that, in the event of special measures due to some trouble, the operating staff are apt to be somewhat wary, and this can also be avoided. Moreover, the maintenance staff can be relieved of routine testing work, and can thus devote more time to more important duties, tests, etc. Also, the reliable working of the track diagram push-button type installation is continually watched by the apparatus, and all human errors in the recording of faults are eliminated. The automatic indication of any trouble in the installation relieves the maintenance staff, and trouble clearance duties can be confined to certain periods of time so that the need for continuous manning might be obviated. The maintenance staff are able to carry out the work at leisure, and during off-peak periods of operation.

For these reasons, it would appear desirable, in the further development of track diagram type signalling installations, to design the intermediate distributor, from the outset, in such a way that testing apparatus can be connected.

[656 .222 .4]

Adapting the track layout to the timetable,

by Dr.-Eng. Gerhard ZIMMER.

(*Signal und Draht*, No. 5, May 1960.)

1. General.

As part of the railway electrification programme, it is intended to raise, in future, the maximum speed of through goods trains to 75 km/h. In conjunction with the higher acceleration of electric locomotives, this speed increase will tend to equalize the running times of all « slow » trains (i.e. local and medium-distance passenger trains, and goods trains), which at present still differ considerably, and will greatly reduce the differences in running times of slow and express trains. There will thus be, in more than one respect, an approach to the ideal of the « parallel » timetable. For, as far as the express trains are concerned, a further increase in the maximum speed beyond 120 km/h is, in many cases, limited by the physical condition of the line which can no longer be improved with economically justifiable means. It is common knowledge that an increase in the maximum speed of express trains does not yield any appreciable gain in running time, unless the train is able to run at the higher speed over long sections. But, in view of the general alignment of our main lines which dates back fifty years or more, this is rarely possible. In the circumstances, the principle of the « parallel » timetable will again assume importance in the future — in particular this principle opens up new possibilities for future operation and track layout.

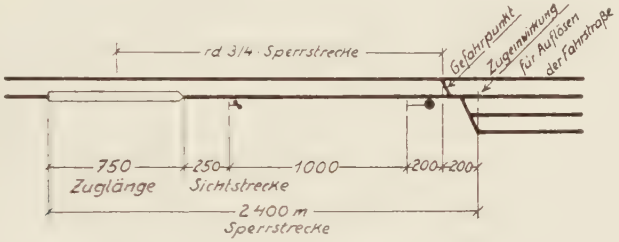

Fig. 1. — The arrival blocking time as a factor determining the basic train interval.

Running time over the blocking distance at a speed of Vg = 72 km/h . . . . 2.4 × 60/72 = 2.0 min

Setting up and cancelling the route, with push-button type signalling. . . . . max. 0.5 min

Blocking time . . . . 2.5 min
Time margin . . . . . 2.5 min

Train interval . . Z = 5.0 min

N. B. — rd 3/4 . Sperrstrecke = approx. 3/4 of blocking distance. — Gefehrpunkt = danger point. — Zugeinwirkung für Auflösen der Fahrstrasse = point at which the train permits the cancellation of the route. — Zuglänge = length of train. — Sichtstrecke = sighting distance. — Sperrstrecke = blocking distance.

2. The principle of the « parallel » timetable.

For the purpose of this discussion, the basic pattern of the « parallel » timetable will be deemed to be represented by the pattern of parallel time-distance lines of through goods trains which, up to a few years ago, were still shown as grey lines in the official graphic timetables. This basic pattern is determined by the train interval and by the time-distance lines of a train of a given weight, hauled by a given locomotive. The following investigations are based on the assumption of an electrically hauled through goods train of 2 000 tons, running at a maximum speed of 75 km/h, hauled by an E 50 locomotive, and having a total length (including locomotive) of 750 m. Having regard to the normal time margin factor, the scheduled speed (slope of the time-distance lines) must be correspondingly lower; it is here assumed to be 75/1.05 = approx. 72 km/h (= 1.2 km/min). The train interval is governed by the minimum headways at which trains running in any direction are able to negotiate certain operational bottlenecks such as major junctions or terminal facilities at major stations. According to figure 1, the train interval is governed by the minimum arrival headway since, for a through train, the minimum interval on the departure side of the station is about the same if the distance between distant starter and starter signal is, as in the case of the home signal, about 1 000 m. For a sequence of conflicting movements, a time margin of 2.5 min is not excessive. In his article entitled « His Majesty, the Time Margin » (*), DILLI even regards a margin of 3 min as desirable. If it is postulated that, at a bottleneck point, it must still be possible for a conflicting movement to be carried out between two trains running in the same direction, one arrives at a train interval of 2 × 5 = 10 min for the basic timetable pattern (fig. 2). On the other hand, a conflicting movement at bottleneck points between two trains running in the same direction will not take place in all cases, as it must be assumed that these bottleneck points are used by a sequence of movements in *any* direction. For that reason, the division of the line into block sections must be based on the time governing the headway at bottleneck points, i.e., in our case Z = 5.0 min. This means that, in the basic timetable pattern, it is still possible to insert a train half-way between two basic pattern lines provided that the bottleneck points negotiated by that train are not, during that basic interval, occupied by conflicting movements (indicated in figure 2 by short broken lines).

3. Advantages and possibilities of adapting the basic timetable pattern to operational key points.

In the following, the term « bottleneck point » will be replaced by « operational key point », thus reflecting the fact that operational key points can be largely deprived of their undesirable bottleneck character if the basic timetable pattern is suitably adapted to the track layout. As figure 2 shows, trains working at 10 min intervals will meet a train running in the opposite direction at intervals of 5 min which, at a running speed of 72 km/h, correspond to sections of 6.0 km length. In a horizontal cross-section of the graphic timetable, the points of intersection with the time-distance lines mark the position of the trains at the corresponding point in time. In figure 2, a horizontal cross-section of this kind is shown at the time of 7.5 min, i.e. exactly half-way between the time at which trains running in opposite directions meet. At this moment, the trains of both directions are equi-distant from each other, the distance between them being the same (6.0 km) as that of the train meeting points. If there is, in figure 2, an operational key point at km 15.0, it would be possible for a train running in the direction from right to left to pass without hindrance, and with the requisite time margins of 2.5 min either way, between two trains running in the opposite direction. But if the operational

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(*) « Eisenbahntechnische Rundschau », 1952, No. 2.

key point is even a short distance away from this point, the time margin available to a preceding or following train is reduced, and the inadequate time margin O is already reached at a distance of 1.5 km on either side of the 15.0 km point. It follows that adequate time margins at operational key points can only be obtained if the latter come to lie close to the half-way points between the intersection points of the basic timetable pattern.

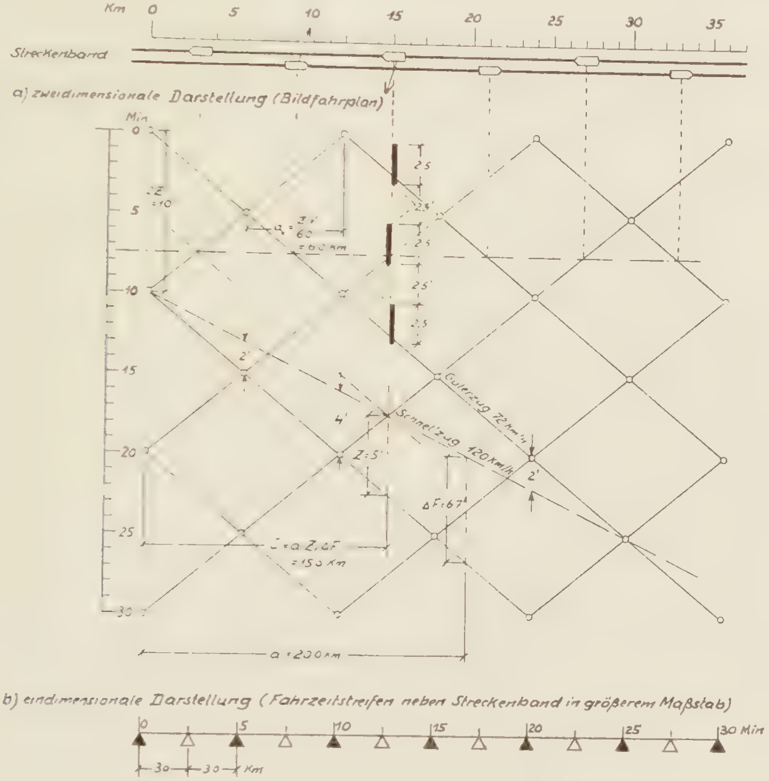
Km
0
5
10
15
20
25
30
35
Streckenband
a) zweidimensionale Darstellung (Bildfahrplan)
Min
0
5
10
15
20
25
30
2,5'
2'
4'
Z=5'
ΔF=67'
Güterzug 72 km/h
Schnellzug 120 km/h
a=200 km
b) eindimensionale Darstellung (Fahrzeitstreifen neben Streckenband in größerem Maßstab)
0
5
10
15
20
25
30 Min
30
30
Km

Fig. 2. — Basic timetable pattern of a double-track railway.

N. B. — Streckenband = distance scale. — Zweidimensionale Darstellung... = two-dimensional representation (graphic timetable). — Eindimensionale Darstellung... = uni-dimensional representation (running time scale shown against distance scale, on an enlarged scale). — Schnellzug = express train. — Güterzug = goods train.

The basic timetable pattern over a section of line can of course only be adapted to one specific operational key point so that the question arises how the remaining operational key points in this section of line should be dealt with. In this case, however, it is possible to resort to systematic two-way track working. If, with right-hand running, a train is due to be diverted to the left, this constitutes a conflicting movement creating an operational key point. But if the train can be switched over to the left-hand track, the diversion does not represent a conflicting movement, and no operational key point is created. An operational key point, though geographically fixed, can thus be eliminated by arranging for two-way track working between that point and the nearest suitable point determined by the basic timetable pattern. In this way, the operational key point is, as it were, shifted from its original location to the two-way crossovers where the two-way track working commences. This will be explained in Section 6 by means of examples.

4. The express train in the basic timetable pattern.

Special comment is called for in regard to the objection that, in the graphic timetable, express trains occupy a position entirely different from that of the trains of the basic pattern so that the idea of adapting the track layout and the basic timetable pattern to each other is liable to lose much of its value. In figure 2, the time-distance line of an express train running at a speed of 120 km/h has been plotted as a broken line, inserted between the time-distance lines of the trains of the basic pattern which run at a speed of 72 km/h. Over a section of 30 km, corresponding to 5 times the distance a_k of the intersection points of the basic pattern, the difference in running times, $\Delta F = 10$ min, is equal to the train interval in the basic pattern. Thus, if the time-distance line of an express train passes through one intersection of the basic pattern (as shown in figure 2) it will also pass through certain other intersection points, provided that the difference in running times over a section corresponding to a whole multiple of the interval of the intersections of the basic pattern exactly corresponds to the train interval in the basic pattern. This condition is kept in such general terms that it can hardly be regarded as imposing an appreciable constraint on the timetable. A closer investigation of the time-distance line of an express train between two intersection points of the basic pattern (at km 0.0 and km 30.0 in figure 2) shows that, although there is a difference of varying magnitude between the passage times of the express train and the trains of the basic pattern at the intermediate intersection points (amounting, according to figure 2, to — 2, — 4, + 4 and + 2 min, respectively), this difference amounts at three out of five intersections to less than the available time margin of 2.5 min. These considerations concerning the features and possibilities of an *organic* insertion of the time-distance lines of express trains into the basic timetable pattern should be sufficient to refute the objection referred to at the beginning of this Section.

5. The influence of the problem of overtaking on the design of the track layout.

The « problem of overtaking » is here meant to comprise the need, in the widest sense, for scheduled or unscheduled changes in the sequence of trains on a double-track railway, not only at stations but also on the open line where overtakings might become necessary in an emergency, e.g. because a train has broken down on the line (e.g. due to a hot axle-box) and must be by-passed on the other track.

According to figure 2, the maximum distance $\ddot{u}$ between overtaking stations on a section of a km length is determined by the proportional equation $\ddot{u} = a \,.\, Z/\Delta F$, where Z is the basic train interval, and ΔF the difference in the running times over the section a. For instance, on the 7.7 km long section from Kattenvenne to Lengerich (Westphalia) on the Wanne-Bremen line, the running time of a steam-hauled through goods train is about 13 min, whilst that of a steam-hauled long-distance express train is no more than 4 min. With a minimum train interval (according to the graphic timetable) of 8 min, the maximum distance between overtaking stations on this section works out at $\ddot{u} = 7.7 \times 8/(13\text{-}4)$ = say, 6.8 km, whilst the distance between Lengerich and the intermediate overtaking station at Ringel is 5.0 km. With electric traction, the speed attainable by a through goods train would be increased to 72 km/h so that its running time over this section would be reduced to $7.7 \times 60/72 = 6.4$ min. But the running time of an express train, running at 120 km/h, would only be reduced to $7.7 \times 60/120 = 3.85$ min. In the circumstances, and with a train interval of $Z = 5.0$ min, the maximum distance between overtaking stations would be increased to $\ddot{u} = 7.7 \times 5/(6.4\text{-}3.85)$ = say, 15.1 km, i.e. to about three times the present inter-station distance between Ringel and Lengerich. But as long as the tracks are signalled for unidirectional working only, it would not be practicable, for operating reasons, to increase the station distances, e.g. through closing certain stations, as this would unduly increase the difficulties for overtaking in an emergency (wrong-road working). This is presumably one of the reasons why, in spite of the reduction in the difference in the running times of fast and slow trains brought about by electrification, the electrification schemes carried out so far have only rarely been associated with a reduction in the comparatively great number of overtaking points, originally required for steam operation. But as a result of recent tendencies to rationalize the operation of the railways by closing down small establishments, the question of closing minor stations, even on main lines, has again become topical. In the circumstances, only two alternative solutions are available for the future design of the operating installations of double-track railways on conversion to electric traction :

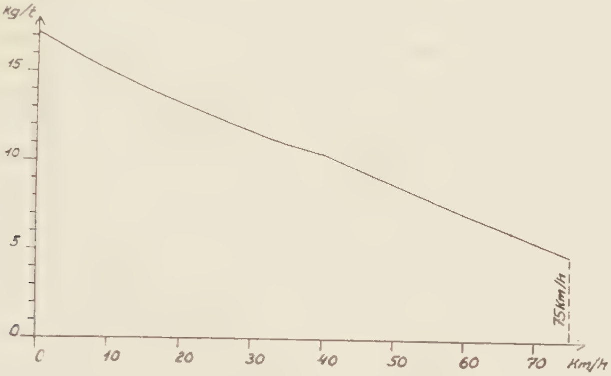

Fig. 3. — Tractive effort-speed characteristic of an E 50 locomotive with a load of 2 000 tons.

I) to retain all the existing stations, modernize their signalling by means of push-button type signalling installations, and equip the line with automatic block system. Unidirectional track working is retained, and the delays due to emergency wrong-road working must be accepted;

II) to close minor stations, inasmuch as this measure can be justified by operating considerations (reduced difference in running times, due to electric traction) and by traffic considerations (rationalisation measures). The longer sections between stations are equipped with automatic block and intermediate crossovers, permitting systematic two-way track working on each track even over shorter sections of line.

In order to make the most of the potentialities of systematic two-way track working, this solution must, of necessity, be associated with the remote control of signalling over a fairly long section of line (between two major junction stations). Also, as explained in Section 3, it is advisable to place the new crossovers half-way between the meeting points of counter-running trains in the basic timetable pattern (« systematic two-way track working without bottlenecks »).

6. Conversion of a section of line for systematic two-way track working without bottlenecks.

Figure 4, illustrates the suggestion, developed in Sections 3 and 5, for « systematic two-way track working without bottlenecks » on the Münster (Westphalia)-Osnabrück section of the line from Wanne to Bremen. As the two-dimensional representation of the graphic timetable is unsuited for the large distance scale, a uni-dimensional form of representation has been developed (cf. fig. 2 *b*) which contains all the data of the basic timetable pattern required for the planning. Here, the well-known representation of the time-distance line as a running time strip is supplemented by small black and white triangular marks. The intersections of the lines of the basic timetable pattern (meeting points of trains running in opposite directions) are marked by black triangles, whilst the half-way points between them, which provide suitable positions for operational key points such as cross-overs, or junctions for conflicting movements, are marked by white triangles. The key junctions nearest to the terminal stations. Münster (Westphalia) and Osnabrück are situated at Sudmühle carriage sidings (km 72.3; junction with the Münster goods loop line) and at Hörne (km 114.0; junction with the second pair of tracks between Hörne and Osnabrück). The distance between these two operational key points is 114.0 — 72.3 = 41.7 km, i.e. only slightly shorter than the distance corresponding to seven times the interval between intersection points of the basic timetable pattern (7 × 6.0 = 42.0 km), as shown in figure 2. In this case, the basic timetable pattern can therefore be so arranged that both junctions come to lie at points marked by white triangles (km 72.2 and 114.2). First, however, it is still necessary to examine, on the basis of the tractive effort-speed characteristic (fig. 3) and the mean rolling resistance, whether the maximum speed of 75 km/h assumed for the basic timetable pattern can in fact be adhered to over the whole section of line concerned. This happens to be the case, since the maximum value of the mean rolling distance, amounting to 4.7 ‰ between, Hohne and Lengerich (Westphalia), is still below the tractive effort of approx. 4.8 kg per ton available at the speed of 75 km/h.

Among the intermediate stations, Lengerich (Westphalia) and Hasbergen (Co. Osnabrück) are major stations with considerable local and interchange traffic, which cannot be closed. Similarly, it will be necessary, for operating reasons, to retain the stations at Sudmühle and Hörne which serve as advance junction points for Münster and Osnabrück, respectively. In Section 5 and figure 2, the maximum distance between overtaking stations has been calculated to be $\ddot{u}$ = 15 km so that, having regard to the retention of the intermediate stations Sudmühle, Lengerich, Hasbergen and Hörne, referred to above, it is only necessary to subdivide the approx. 26 km long section between Sudmühle and Lengerich by providing a station for overtaking purposes. A station suitable for this purpose is Brock-Ostbevern.

In addition to the key junctions at Sudmühle and Hörne already referred to, it is also necessary, under present track layout conditions, to regard the entrances and exits of the local goods yards at Lengerich and Hasbergen, in the direction from Bremen to Wanne (empty wagons), as operational key points since they give rise to conflicting movements.

With the basic timetable pattern here adopted, the position of the departure crossover at Hasbergen happens to coincide with a « white triangle » position (at km 108.2) so that this crossover is correctly situated from an operating point of view. But at the arrival crossover at the other end of Hasbergen goods yard, some 1 km away, the time margin of 2.5 min available at the departure crossover would already be reduced to 2 × 1.0 × 60/72 = say, 1.7 min so that the remaining time margin of 0.8 min would be inadequate. It would therefore be preferable to divert a goods train entering Hasbergen yard to the left-hand track from Hörne to Hasbergen. In that case, the train in the opposite direction, meeting this train at km 111.2 (black triangle), would also have to use the left-hand track from Hasbergen to Hörne.

At Lengerich (Westphalia), a train meeting point (black triangle at km 99.2) is situated within the station area so that in this case, in contrast to Hasbergen where

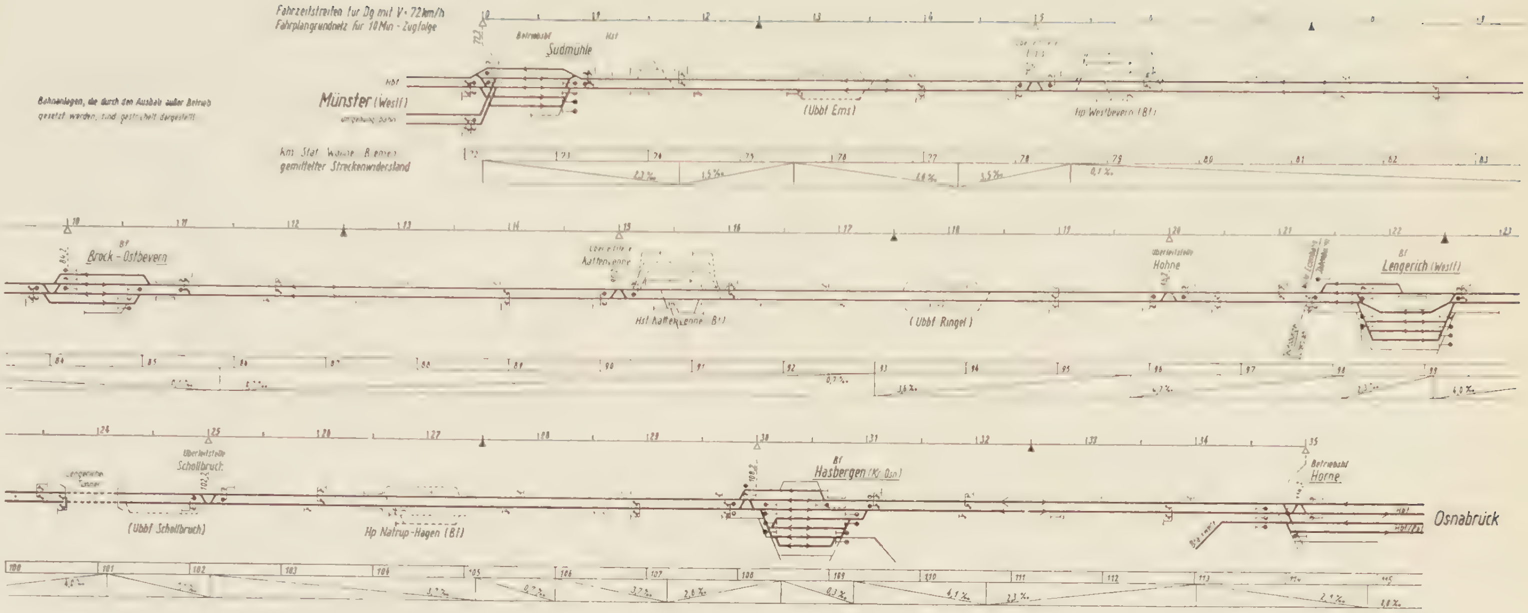

Fig. 4. — Conversion of a section of line to systematic two-way track working without bottlenecks.

N. B. — Bahnanlagen, die durch... = installations to be removed as a result of the conversion are shown in broken lines. — Fahrzeitstreifen... = running time scale for a through goods train running at V = 72 km/h. — Fahrplangrundnetz... = basic timetable pattern for train intervals of 10 min. — Km-Stat. Wanne-Bremen — kilometrage from Wanne to Bremen. — Gemittelter Streckenwiderstand = mean rolling resistance. — Überleitstelle = crossovers for two-way track working.

the need for using the other track is confined to the conflicting arrival movement, it will also be necessary to use the other track for the conflicting departure movement. The corresponding crossovers are located at Schollbruch (km 102.2) on the arrival side, and at Hohne (km 96.2) on the departure side.

Further two-way crossovers are envisaged at Ems (km 78.2) and at Kattenvenne (km 90.2) (replacing the existing crossovers for wrong-way working at Ems, Westbevern and Kattenvenne stations which would be closed) so as to obtain an adequate sub-division of the long sections between the remaining stations for emergency left-hand working which would then, however, be properly signalled.

The crossovers would have to be equipped with points of type 49 — 760 — 1 : 14 which permit a maximum speed of 80 km/h over the deviation. As far as *scheduled* left-hand running is concerned, this would therefore have to be confined to trains of the basic pattern, whilst express trains with speeds of 120 km/h and more would not be suitable.

For normal right-hand running, the automatic block sections corresponding to the sections between the stations and the two-way crossover points are based on a train interval of Z = 5.0 min, with 1 min time margin. With automatic block working, the blocking time is equal to the running time of the train over the blocking distance. Assuming a distance of 1.0 km between the rear of the train and the distant signal (cf. fig. 1), a distance of 1.0 km between distant signal and main signal, a distance of a km between successive automatic block signals, and a distance of 0.2 km between the second automatic block signal and the point at which the train permits the cancellation of the route, the blocking time is equal to $(a + 2.2) \times 60/V$ min. With $V = 72$ km/h and a specified blocking time of $5 - 1 = 4$ min, one obtains a maximum automatic block signal spacing of $a = 4 \times 72/60 - 2.2 = 2.6$ km. For left-hand running, a further sub-division by automatic block signals of the sections of line referred to above is not contemplated.

The method, here described, of systematically locating the operational key points (conflicting route movements; crossovers) at selected points of the basic timetable pattern is not confined to the case, assumed in the above example, of a constant speed of the trains of the basic pattern over the whole section of line: the method can also be used if a different speed applies to a given section (e.g. on a heavy gradient). In this case, too, the meeting points of trains running in opposite directions, in accordance with a pattern based on a given operational key point, can easily be determined from the running time characteristics for each direction.

It is relevant to point out one special advantage of the two-way crossovers for two-way track working: These crossovers can be provided at almost any point of a double-track railway (with comparatively rare exceptions such as long bridges, or sections where the two tracks are on different levels). The arrangement here proposed, based on two-way track working without bottlenecks, is therefore almost independent of the operational key points governed by the route alignment and the position of the stations.

7. Cost estimate and conclusions.

For the example referred to in Section 5, viz., the line from Münster (Westphalia) to Osnabrück, a broad comparison has been prepared of the costs of the alternative solutions I (unidirectional track working) and II (systematic two-way track working without bottlenecks). The estimate for both alternatives is based on the assumption of electric traction. Moreover, solution I assumes the existence of automatic block signalling and of push-button type signalling installations, as well as the retention of all existing stations. Solution II presupposes, in addition, the remote control of the signalling installations but assumes the closure of certain stations in accordance with the possibilities afforded by electric traction (reduced difference in running times).

That portion of the capital cost which

is about the same for both alternatives, does not affect the comparison and can be ignored. This consideration also applies, inter alia, to the railway telecommunications system, since the reduced cost of local telecommunication systems associated with solution II, where operation is remote-controlled, is balanced by the extra cost of the necessary long-distance connections to the line controller. The estimates have therefore been confined to the *additional* items of expenditure associated with each alternative solution, i.e. those items which are not, or not to the same extent, associated with the other solution as well. The results of this estimate are

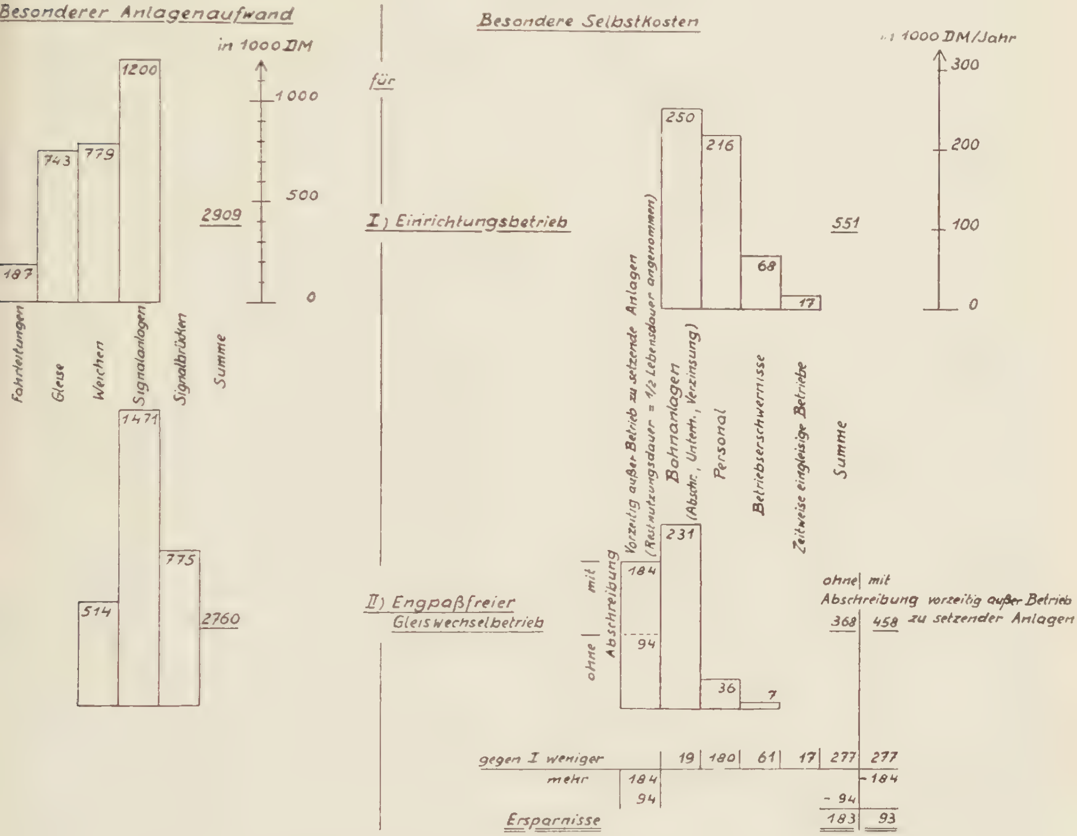

Fig. 5. — Comparative cost estimates for the line from Münster to Osnabrück.

N. B. — Besonderer Anlagenaufwand = excess capital cost. — Fahrleitungen = catenary. — Gleise = tracks. — Weichen = points. — Signalanlagen = signalling installations. — Signalbrücken = signal gantries. — Summe = total. — Besondere Selbstkosten = excess annual costs. — Vorzeitig ausser Betrieb zu setzende Anlagen = installations to be removed prematurely. — Restnutzungsdauer : 1/2 lebensdauer angenommen = residual life assumed to be equal to half the service life. — Abschreibung = depreciation. — Bahnanlagen (Abschr., Unterh., Verzinsung) = railway installations (depreciation, maintenance, interest). — Personal = staff. — Betriebserschwernisse = operating impediments. — Zeitweise eingleisige Betriebe = temporary single-line working. — Summe = total. — Ohne/mit Abschreibung vorzeitig ausser Betrieb zu setzender Anlagen = without/with depreciation of installations which must be removed prematurely. — I) Einrichtungsbetrieb = unidirectional track working. — II) Engpassfreier Gleiswechselbetrieb = systematic two-way track working without bottlenecks. — Gegen I weniger = savings compared with I. — Gegen I mehr = excess cost compared with I. — Ersparnisse = savings (on balance). — 1 000 DM/Jahr = 1 000 DM/year.

graphically compared, for both solutions, in figure 5.

Excess capital expenditure is divided into catenary, tracks, points, signalling installations, and signal gantries. In the case of solution I (unidirectional working), the excess capital expenditure arises from the cost of the overtaking loops at Ems, Westbevern, Kattenvenne, Ringel, Schollbruch and Natrup-Hagen which are not needed for solution II. In the case of solution II, the excess capital expenditure arises from the cost of the crossover installations at Ems, Kattenvenne, Hohne and Schollbruch, and of the corresponding track connections at Hörne. Certain minor modifications of the track layout at Sudmühle, Brock-Ostbevern, Lengerich and Hasbergen stations, required for their adaptation to systematic two-way track working, can be carried out without extra cost on the occasion of scheduled permanent way renewal works, especially as the conversion is usually associated with a reduction in the number of points. The higher cost of signalling installations in the case of solution II is due to the two-way track working and to the remote control of the signalling installations between Sudmühle and Hörne, assuming that the line signal box is located at Lengerich, near the centre of the section of line, and that all other signalling posts are remote-controlled from there, with the exception of Sudmühle and Hörne stations which still belong to the zone of influence of Münster and Osnabrück stations, respectively, and of Hasbergen station which, being a junction station, must be manned with a station inspector of its own who must, however, accept orders as far as the main line working is concerned.

With two-way track working, a considerable part of the capital cost is represented by the signal gantries (cantilevered over two tracks). Here, the question arises whether one could not, with signalled left-hand running, also permit a positioning of the signals on the left side of the track so as to save the cost of the gantries.

The excess annual costs consist of depreciation, maintenance and interest in respect of the additional capital assets, and of the excess costs, different for each solution, of staff, operating impediments (due to conflicting movements and to emergency wrong-road working and left-hand running) and, with unidirectional working only, of the extra cost of emergency crossovers and signalling installations which must be kept available for temporary single-line workings.

In practice, it will hardly ever be possible to carry out a conversion of a long section of line to systematic two-way track working at a time when all the installations to be removed as a result of the conversion happen to be life-expired. Solution II must therefore also be debited with the cost of depreciation and interest of the installations that must be prematurely removed. These costs increase with the residual service life of the individual installations at the time of conversion. The values here used are based on the assumption that the installations to be removed have, at the time of the conversion, just completed half of their service life. In this connection, the catenary has not been taken into account since the section of line concerned is at present not yet electrified so that it would still appear possible to combine the suggested conversion with the electrification.

In spite of the considerable financial burden imposed by the prematurely removed capital assets, the comparison of the additional costs of the two alternative solutions reveals the economic superiority of systematic two-way track working. By way of conclusion, it may be permitted to quote an extract from the speech recently made by the President of the Swiss Federal Railways on the occasion of the 75th anniversary of the Gotthard Railway (*) :

« In future, remote control posts will be equipped with prepared working programmes for automatic operation. This will render operation more rapid and fluid, and more economic in manpower without prejudice to safety. Train crossings and overtakings will no longer be confined to given points, and running in a given direction will no longer be confined to a given track. »

(*) From the journal « Verkehr », Vienna, No. 27. 1957, pp. 849 and 868.

[385 (06 (4)]

European Conference :
« Technical Progress and the Common Market ».

The Commissions of the European Economic Community and European Atomic Energy Community, as well as the High Authority of the European Coal and Steel Community jointly organised from the 5th to the 10th December 1960, in Brussels, an European Conference on the theme : « Technical Progress and the Common Market ».

We think our readers would be interested in the conclusions, given below, which were discussed by the Sub-Group « Railways » of the Working Group « Transport » and passed at the plenary meeting of the latter.

The main reporter of the « Railways » Sub-Group was Professor F. SANTORO, Manager of the Commercial and Traffic Department of the Italian State Railways, assisted by Professor R. KLEIN of Darmstadt Higher Technical School, Mr. A. THEATO, Chief Engineer of the Luxemburg Railways, and Mr. J. WALTER, Head of the Safety Installations, Telecommunications and Catenaries Department of the French National Railways, reporters.

CONCLUSIONS.

Railways.

1. It would appear that, taken as a whole, the productivity of the railways, on the one hand, and the quality of the services, on the other, have been considerably improved, thanks to technical progress.

This favourable evolution which has been characterised in particular by a considerable increase in the services demanded of transport and at the same time a reduction in the overall working hours, is certain to continue.

2. The productivity of the railways has particularly increased in those cases where, there being a great amount of traffic, it has been possible to take advantage of technical progress as a result of appropriate capital investments.

It is therefore in such cases as these that capital investments are the most economic and should justly have priority.

3. The Common Market will lead to an increase in exchanges of railway traffic between the six member countries.

Under these conditions, the Commission for European Economic Community should take steps to promote technical progress in order to achieve a railway system which will be able to meet the demands of the future.

4. The general capital investment programme should therefore make it possible to perfect the equipment of the railways, so that they will be able to obtain from technical progress all the essential advantages expected. Electrification, dieselization, extension of telecommunications, increased automation, mechanisation of the permanent way work, rationalisation of the traction and rolling stock, amongst other things, must be rapidly developed, owing to their value from the general point of view, a value characterised by improved efficiency of the railways, a reduction in its operating expenses, the elimination of arduous or dangerous duties as far as the staff is concerned, etc. Under these conditions such a perfecting of the railway equipment will have as its result that, even more than is the case at the present time, and without building any new lines, there will be a reserve of transport capacity, a reserve the rational utilisation of which cannot but benefit the community.

5. The difficult financial position of the railways has often proved an obstacle in

the way of renewing and modernising their equipment.

It is therefore very desirable that this position should be put on a sound basis, in particular by allowing the railway administrations to have a tariff policy based on commercial principles to a far greater extent than is the case at the present time.

6. The application of modern techniques has made it possible for the railways to improve considerably the remuneration and working conditions of their employees.

Taking advantage to a greater extent of technical progress will in the long run prove to be the essential condition for the realisation of new social improvements without undesirable repercussions on the community and without any reduction in the competitive capacity of the railways.

It is desirable to extend studies into the effects of technical progress upon the working conditions and remuneration of the railway staff, compared with the position of workers in other industrial sectors, and taking into account the standards of living of each country.

NEW BOOKS AND PUBLICATIONS.

[**656** .25]

LEMONNIER (André). Honorary Chief Engineer, French National Railways. **L'exploitation technique du Chemin de fer — La Sécurité du Transport.** — (*Technical working of the railway — Safe transport.*) — One volume (6 1/4 × 9 3/4 in.) of 176 pages with 49 figures and 9 photographic plates. — 1960, Paris (V^{e}), Editions Eyrolles, 61, boulevard Saint-Germain. (Price : 20.20 NF.).

The second edition (1960) of Mr. A. LEMONNIER's work will be read easily and pleasurably. Although since 1945 (the date of the first edition), the forms of and ways of making the installations which assure safety in transport have certainly shown a tendency towards facility of use and the extension of the zones controlled, the principles upon which safety is based have not varied. Mr. LEMONNIER has devoted himself to a clear and reasoned explanation of this and not to a complete dogmatic report. Naturally French designs are stressed, both those of the S.N.C.F. and the other railways which preceded them, but other forms of signalling are also mentioned and compared with them.

The book can be divided logically into three parts, studying the methods employed to avoid respectively overtaking (block-system), collisions at points (signalling) and collisions on single track.

The first part, after recalling the principles of the block system, describes the forms in use, several of which are still used : Regnault, Tyer, Lartigue (the latter can be fitted with « continuity » equipment), and then the principle of the track circuit and the automatic block. The French regulations on the block system are given, including the precautions to be taken when running at caution.

Points and crossings are places where collisions are possible. For this reason, train movements have to be authorised or forbidden by signals. Unlike the indications used in the case of the block system (semaphores) where the indications may be « permissive », in this case they are absolutely imperative. They have therefore to be completed by « warning signals » (and sometimes even by « prewarning » signals when the braking distance is greater than the signal spacing), such as « slow down » signals and « remember to slow down ». The form of the signals (especially colour light signals) in France are derived from those recommended by the « Verlant » Commission. Interlocking is obtained in various ways, amongst which the centralised train control (C.T.C.) in the signal boxes gives rise to transit problems. The most recent signalboxes with free levers or buttons are of the P.R.S. type. Cab signalling and automatic braking are also studied.

The last part, relating to collisions between trains, deals above all with the working of single lines. Alterations in the working timetable are made in America by orders to the trains given by the dispatcher; in Great Britain and several of the Dominions, the train-staff is used. In France, telephoned orders are used, and more recently and frequently the single track block system.

The final chapter deals with the working and arrangement of single track stations.

The book also includes 9 plates in addition to the text which are of the greatest interest.

P. Sch.

[**385** (05]

Jahrbuch des Eisenbahnwesens. Folge 11. 1960 (*Annual review of railway questions. 11th year 1960*). **125 Jahre deutsche Eisenbahn** (*125th anniversary of the German railways*). — Edited by Professor Dr.-Eng. Th. VOGEL, President of the Central Office of the Bundesbahn, Munich. One volume (8 1/4 11 1/2 in.) of 252 pages of text, with numerous tables, drawings and illustrations. — 1960, Darmstadt, Carl Röhrig Verlag, Holzhofallee, 33*a*. (Price: 14.80 DM.).

This volume is the eleventh annual publication of the « Jahrbuch des Eisenbahnwesens ». Faithful to tradition, a whole series of remarkable articles are devoted to the evolution of the various railway techniques and to certain questions closely linked up therewith.

In his editorial, Dr. L. SEIERMANN, Secretary of State, defines the important part played by methods of transport and in particular by the railway on the international plane since the previous century. He then comments upon the various organisations of an European character set up since 1947. In his conclusion, he recalls that the railway, as well as other methods of transport, collaborates in improving living conditions and the stability of international political relations.

In a particularly interesting article, Prof.-Dr.-Eng. K. LEIBBRAND shows how the evolution of the structure of the cities is conditioned by transport problems. Another article is devoted to « the leading idea in the transport industry ».

The following articles deal in turn with: the reconstruction of Berne station, automation in signalling (carried out on the Ludvika-Oxelösund line), the electrical industry exhibition in Paris (June 1959), the V 160 Diesel locomotive of the Deutsche Bundesbahn, and ten years of research and international trials within the framework of O.R.E.

An important article is devoted to the history of the German Railways, which have just celebrated their 125th anniversary, and to the most recent developments on the Deutsche Bundesbahn.

Another contribution to the history of the railways is the review of the evolution of the stock of coaches and wagons on the Bavarian State Railways.

The work ends with a report on the activities of the Deutsche Bundesbahn in 1959, a review of the researches and technical realisations carried out by various Railway Administrations during the year 1959, and finally statistical data covering all the railways of the world.

W. v. R

[**385** (09 .3 (43)]

1835-1960 : 125 Jahre deutsche Eisenbahnen (*125th Anniversary of the German Railways*). — Special issue of the review *Die Bundesbahn*, November 1960. — A pamphlet (8 1/4 11 1/2 in.) of 170 pages of text with numerous illustrations and coloured plates. — 1960, Publisher Carl Röhrig, Verlag, Darmstadt, 33*a*, Holzhofallee. (Price : 8.8 DM).

The well known review « Die Bundesbahn » has devoted a special number to the 125th Anniversary of the German Railways.

The introduction gives a brief history of the development of the German Railway network since 1835.

The most important part of the number deals successively with the activities of each of the sixteen Regional Managements.

After a report of the special economic features of the region, detailed reports are given of the goods and passenger traffic, the operating characteristics, any special signalling and permanent way work, the importance of the traction and rolling stock, the number of employees, as well as the introduction of the latest techniques.

Copiously illustrated, with maps and extracts, this special number is in fact a very thorough study of the activities and present position of the Deutsche Bundesbahn.

W. v. R.

MONTHLY BIBLIOGRAPHY OF RAILWAYS (1)

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(MAY 1961)

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Paris (6e), Dunod, éditeur, 92, rue Bonaparte. Un ume relié (16 × 25 cm) de 411 pages avec 76 figures. ix : 49 NF.)

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Exercices numériques de mécanique des fluides et de rmodynamique.

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ELS (R.). — **De spoorwegen in Japan.** (*Slot.*) (1 200
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1959 **656** .256 = 491 .85
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WYSOCKI (S.). — Essais de la **signalisation avec feux clignotants.** (800 mots & tableaux.)

1959 **621** .31 = 491 .85
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ZACHARSKI (S.). — **Convertisseurs de tension aux transistors.** (1 100 mots & fig.)

1959 **621** .332 = 491 .85
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JAMIOLKOWSKI (J.). — **Caténaires en acier-aluminium.** (1 700 mots & fig.)

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WINKOWSKI (J.). — **Machines électroniques numériques.** (1 800 mots.)

1959 **656** .256 = 491 .85
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MIGACZ (T.). — **Installations électriques de sécurité à enclenchement inversé.** (1 900 mots & fig.)

In Portuguese.

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1961 **656** .2 (83)
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1959 **624** (47) = 491 .7
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ANDRYANOV (B.D.). — **Construction d'un pont sur le fleuve Oural.** (600 mots & fig.)

1959 **625** .12 = 491 .7
Transportnoïé Stroïtyélstvo, juillet, p. 17.
SAATTCHYANE (G.G.) et TZVYÉLODOUB (B.I.). — **Amélioration de la qualité de construction de la voie terrestre.** (2 300 mots.)

1959 **725** .31 = 491 .7
Transportnoïé Stroïtyélstvo, juillet, p. 27.
TCHOUPRINE (L.M.). — **Nouveaux projets typiques de gares ferroviaires.** (1 200 mots & fig.)

1959 **691** = 49
Transportnoïé Stroïtyélstvo, juillet, p. 40.
SSISOV (W.P.). — **L'intérêt de l'emploi de sab grains fins dans le béton.** (1 600 mots, tableaux & fig.)

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KONDRACHOV (D.S.) et LOPAÏ (S.D.). — **Cons tion de la superstructure de la voie par transport préa du ballast et épandage de celui-ci sur la voie.** (1 300 & fig.)

1959 **621** .87 = 49
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YÉSKINE (W.E.). — Le rendement économiqu l'**application d'excavateurs** dans une construction nouv (1 200 mots & tableaux.)

1959 **624** .2 = 49
Transportnoïé Stroïtyélstvo, août, p. 21.
KOUSMINE (E.M.) et SMIRNOVA (L.S.). — **struction de longues poutres précontraintes** avec dép ment des armatures dans les canaux ouverts. (1 000 & fig.)

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1959 **625** .12 = 49
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CHI TCHJOUNE-KHEN. — Examen de la **comp du sol** à l'aide des rayons radio-actifs. (2 300 mots &

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ORKAN (L.). — **La situation actuelle et le dévelop-**
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ERNAS (V.). — **Le rendement économique des dépen-**
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ŠEK (F.). — Considérations sur la **circulation des**
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, tableaux & fig.)

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LANÍK (R.). — **Marche des trains en variation de**
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LANT (I.). — **L'étude de la marche des wagons** à
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0 mots & fig.)

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KLIMEŠ (F.), JAVORNICKÝ (J.) et MILBAUER (M.). — Recherche des **causes d'enfoncement des selles de rails** dans les traverses en bois. (3 900 mots, tableaux & fig.)

1959 **656** .222 = 91 .886
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KOBLASA (K.). — **Application d'une installation automatique de sécurité à un sens de marche pendant la marche à contre-voie.** (1 500 mots & fig.)

1959 **625** .172 = 91 .886
Železniční Doprava a Technika, septembre, p. 285.

KAVÁLEK (L.) et STRAKA (B.). — **L'entretien des parties lourdes de la superstructure.** (1 600 mots & fig.)

1959 **656** .222 .6 = 91 .886
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ŠIBRAVA (M.). — Méthodes de calcul d'un **plan de formation des trains de wagons-tombereaux vides.** (2 000 mots & fig.)

1959 **656** .212 .5 = 91 .886
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ROZTOČIL (F.). — **Rendement des gares de triage.** (4 600 mots & fig.)

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BÁRTA (V.). — **Comparaison complexe de l'intérêt économique de différentes variantes d'investissements proposés et de la succession technologique.** (3 100 mots & fig.)

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KROŇDÁK (M.). — **Plan de formation de trains homogènes** — détermination d'une rame de wagons optimum. (2 800 mots & fig.)

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Železniční Doprava a Technika, octobre, p. 306.

VYSUČEK (K.). — **Problème d'assurance de conformité entre le tableau de marche des trains et la technologie de fonctionnement d'une gare de triage.** (3 600 mots & fig.)

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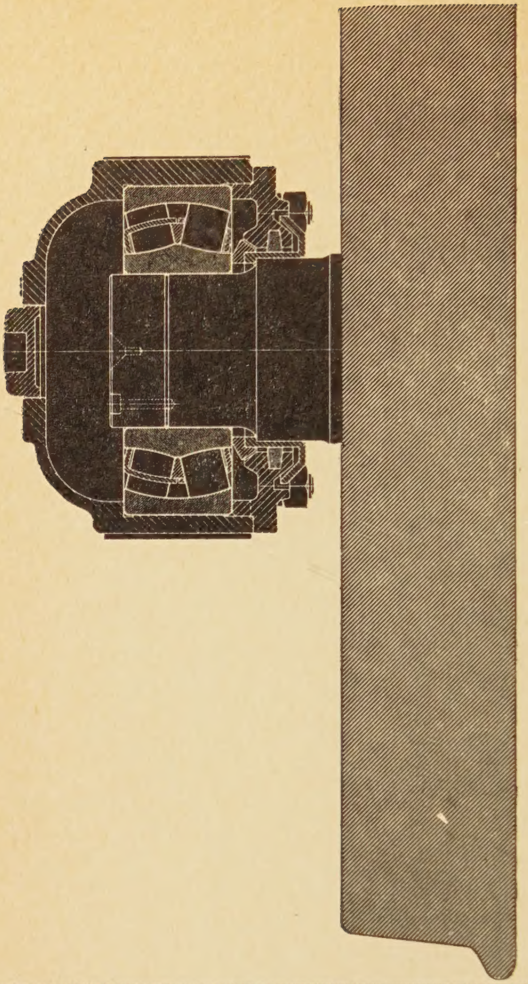

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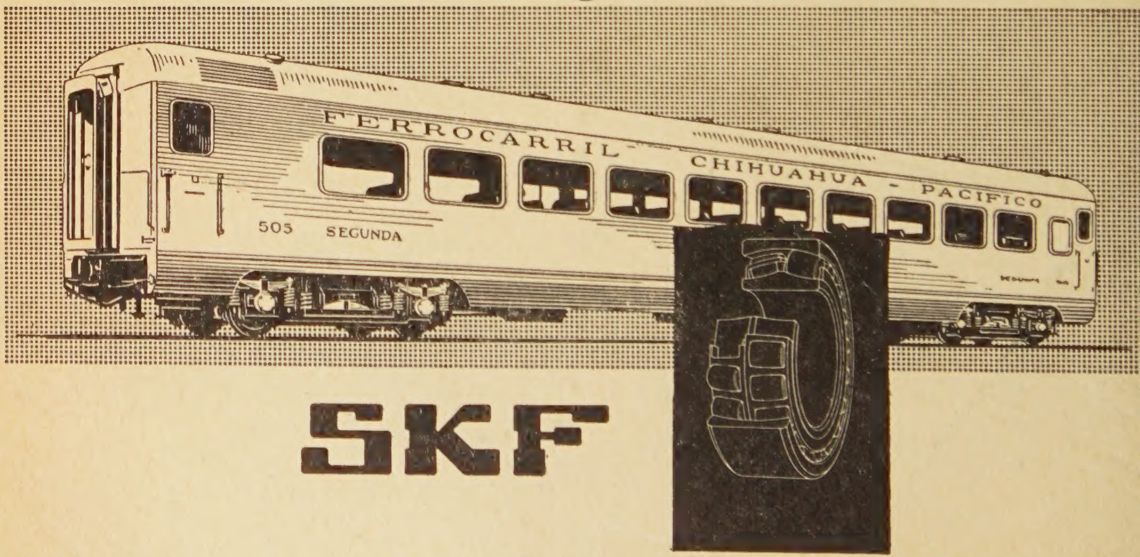

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